



**ACTIVE SCHOOLS: SKELMERSDALE (AS:SK) –
INTERVENTION APPROACHES TO PROMOTE
PRIMARY SCHOOL PHYSICAL ACTIVITY IN A HIGH
DEPRIVATION COMMUNITY**

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Nil Satis Nisi Optimum

Abstract

Participation in physical activity (PA) during childhood, particularly PA of a moderate to vigorous intensity, is important for many aspects of physical and psychological health. Numerous barriers can prevent children from engaging in PA during their free time. Therefore, schools are important settings for providing children with opportunities to engage in health enhancing PA. There is a need for school-based PA strategies which can be 'self-sustained' by schools. The main aim of this thesis was to explore intervention approaches which had no or limited financial cost and were implemented by existing school staff structures with the aim of promoting primary school PA in a low socio-economic status community.

Chapter 4 (Study 1) established that PA levels were low and school-based PA strategies are warranted. Furthermore, the use of multilevel analyses established a range of child- and school-level factors which predict PA participation during segmented school time. Initially, single-component school-based PA strategies were implemented in Chapter 5 (Study 2). Implementation challenges related to space within the school environment, and competing demands of teachers and other members of staff, such as timetable constraints and other additional responsibilities. The active classroom break and daily Born To Move video interventions indicated positive effects on levels of moderate to vigorous PA (MVPA) and sedentary time (ST). Adaptations to the intervention strategies outlined in Chapter 5 (Study 2) were made based on the study findings. They were then combined with four other school-based PA strategies in Chapter 6 (Study 3) in order to implement and evaluate a pilot multi-component school-based PA clustered randomised controlled trial. The Active Schools:

Skelmersdale (AS:Sk) multi-component intervention had a significant effect on school day ST (significantly less for intervention children by nine minutes per day compared to control group). Chapter 7 (Study 4) explored how the AS:Sk intervention was implemented in participating schools. Implementation differed between schools and study findings advocate school-based PA strategies that are flexible and adaptable in nature. This thesis contributes to the understanding of feasible and acceptable PA strategies in the school setting. Future research is needed to establish school-based strategies that are effective at increasing MVPA levels.

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List of abbreviations

100 MC	100 Mile Club
AB	Active classroom breaks
AG	ActiGraph
APHV	Age from peak height velocity
AS:Sk	Active Schools: Skelmersdale
BMI	Body mass index
BTM	Born To Move
CONSORT	Consolidated Standards of Reporting Trials
CRF	Cardiorespiratory fitness
CSPAP	Comprehensive school physical activity programme
CYP	Children and young people
DM	Daily Mile
ENMO	Euclidean norm minus one
GA	GeneActiv
ICAD	International Children's Accelerometry Database
IMD	Index of Multiple Deprivation
LPA	Light physical activity
MET	Metabolic equivalent
MPA	Moderate physical activity
MRC	Medical Research Council
MVPA	Moderate to vigorous physical activity
Ofsted	The Office for Standards in Education

NCMP	National Child Measurement Programme
PA	Physical activity
PE	Physical education
RCT	Randomised controlled trial
SB	Sedentary behaviour
SD	Standard deviation
SES	Socio-economic status
ST	Sedentary time
TEO	Theory of Expanded, Extended, and Enhanced Opportunities
VPA	Vigorous physical activity
WDST	Write, draw, show and tell
WHtR	Waist-to-height ratio
WLSP	West Lancashire Sport Partnership
YPAPM	Youth Physical Activity Promotion Model

Chapter 1: Introduction

1.1 The Research Problem

Physical activity (PA) is defined as any bodily movement produced by skeletal muscles that results in energy expenditure (Caspersen, Powell, & Christenson, 1985). PA in daily life could occur as a sporting, household or occupational activity (Caspersen et al., 1985). PA differs from exercise, as exercise is a planned and structured activity that has an objective to improve or maintain physical fitness (Caspersen et al., 1985). Opportunities for children to be physically active exist in many different settings and contexts such as within school, at home, at recreation facilities, within open spaces and also through commuting (Perry, Ackert, Sallis, Glanz, & Saelens, 2016). The characteristics of children's PA is said to be spontaneous, short-term and intermittent (less than 10 seconds), and high-intensity (Ratelle et al., 2004).

Participation in PA during childhood, particularly moderate to vigorous intensity PA (MVPA), is important for many aspects of physical health (Janssen & LeBlanc, 2010). Wider positive effects of PA participation are also evident in mental health (Ahn & Fedewa, 2011). These important benefits offer great incentive for providing children with sufficient opportunities to be physically active. Furthermore, although tracking of PA from childhood to adolescence is low to moderate (Telama, 2009), high levels of PA between the ages of nine to 18 have been shown to significantly predict high levels of adult PA in a 21-year tracking study (Telama et al., 2005). Also, fundamental movement skills proficiency, competence, and perceived competence in children have been shown to increase the likelihood of adolescent PA participation (Barnett, van Beurden, Morgan, Brooks, & Beard, 2009). The development of motor skill competence is a primary underlying mechanism which promotes engagement in PA

and the relationship between motor skill competence and PA emerged in childhood will continue to gain strength into adulthood (Stodden et al., 2008). This evidence relating to health benefits and lifelong engagement in PA, is the basis for various national guidelines across the world which state that children and young people (CYP) should engage in 60 minutes of MVPA every day (Australian Government, 2017; Chief Medical Officer Department of Health, 2011; Health Council of the Netherlands, 2017; Tremblay, Carson, et al., 2016; U.S. Department of Health and Human Services, 2008a).

PA data from a UK cohort showed that time spent in MVPA per day reduces from ages five to six to ages eight to nine (Jago et al., 2017). Further worldwide data have revealed that 80% of 13-15 year olds do not meet the 60 minutes of MVPA per day guidelines (Hallal et al., 2012). Consistent with these figures from 2012, more recent worldwide data revealed a high prevalence of inactivity amongst 11-17 year olds (Sallis et al., 2016). Among this data from 2016, 78% of boys and 84% of girls were insufficiently active (Sallis et al., 2016). In addition to this, primary school children spend 55% of their time sedentary and this increases with age (Cooper et al., 2015; Spittaels et al., 2012). Time spent sedentary, defined as any waking behaviour characterised by an energy expenditure of 1.5 METs or less while in a sitting or reclining posture, is detrimental to many aspects of health and therefore should also be limited during childhood (Carson, Hunter, Kuzik, Gray, et al., 2016; Sedentary Behaviour Research Network, 2012).

PA is a complex behaviour that can be influenced by several individual and environmental factors (Bauman et al., 2012). Socio-economic status (SES) is an

example influential factor on PA participation. The World Health Organisation define health inequalities as differences in health status or in the distribution of health determinants between different population groups (Mindell, Ison, & Joffe, 2003). When attributable to the external environment and conditions mainly outside the control of the individuals concerned, the uneven distribution may be unnecessary and avoidable as well as unjust and unfair (Mindell, Ison, & Joffe, 2003). An example health outcome with evident inequalities across the SES spectrum is childhood obesity (National Statistics, 2017a). Obesity related inequalities are most relevant to the AS:Sk study, as figures within Skelmersdale are above national averages (National Statistics, 2017a). In relation to PA inequalities, greater opportunities to engage in sedentary time (ST) have been reported in lower SES homes (Tandon et al., 2012), and wider environmental factors such as crime and safety prevent PA participation in lower SES environments (Eyre, Duncan, Birch, & Cox, 2014). Given the array of factors within a child's life which can influence and shape activity behaviours, schools have been identified as key environments of opportunity to promote PA regardless of children's individual life circumstances (Naylor & McKay, 2009). Also, Public Health England state that targeting children and providing children with the best start in life, for example having sufficient opportunities to be active due to the adverse impact on health which an inactive lifestyle can have, is a fundamental part of improving health and reducing health inequalities (Public Health England, 2017a).

The school setting is an appropriate environment for childhood PA promotion as CYP spend a large amount of waking hours there (40-45%; up to 8 hours). School-based opportunities which children are provided with to engage in PA include: active

commuting, daily recess, physical education (PE) lessons, classroom-based activity, as well as before school and after school clubs. However, teachers have repeatedly reported that a lack of time can prevent daily PA from being implemented (Weatherson, McKay, Gainforth, & Jung, 2017). Increasing curriculum demands means that children are spending large amounts of time sedentary engaging in traditional classroom-based seated learning and this can account for up to 65% of their time at school (van Stralen et al., 2014).

PA interventions have explored various school-based strategies, with a general consensus in the literature that multi-component interventions hold the most promise for having a positive effect on PA levels (Murillo Pardo et al., 2013). Resultantly the comprehensive school PA programme (CSPAP) was proposed by the Centres for Diseases Control and Prevention in the US (Elliot, Erwin, Hall, & Heidorn, 2013). This ideology comprises five different components or points of intervention including PE, PA during school, PA before and after school, staff involvement, and family and community involvement, thus developing a school culture conducive to promoting lifelong PA (Erwin, Beighle, Carson, & Castelli, 2013). This approach to school PA promotion holds much promise as a solution to engaging CYP in PA (Chen & Gu, 2017).

Although teachers have reported numerous barriers to PA implementation (van den Berg et al., 2017), schools have more of a responsibility towards PA promotion arguably than ever before. PA recommendations are increasingly being made in reference to school hours. For example in the United States, the Institute of Medicine's Committee on PA in the school environment recommend that more than half of the recommended 60 minutes of MVPA should be accomplished during school

hours (Committee on Physical Activity and Physical Education in the School Environment, Food and Nutrition Board, & Institute of Medicine, 2013). The UK Government reinforced this in their 2016 Childhood Obesity Strategy stating that schools should provide opportunities for children to engage in 30 minutes of MVPA per school day (HM Government, 2016). Ofsted school inspections now also consider the steps taken by schools to promote PA (HM Government, 2016). There is therefore a need for multi-component school-based interventions which can aid schools and school staff to engage their pupils with 30 minutes of MVPA per day. Due to the added responsibilities which schools now have in relation to PA promotion, strategies are needed that can be sustained once intervention trial periods end. Follow-up (12-month or longer) results of previous PA interventions have not always demonstrated sustained positive effects on PA (Gorely et al., 2011; Harrington et al., 2018).

1.2 Conceptual Framework

Medical Research Council (MRC) guidelines for the development of complex interventions state that drawing upon theory is a key task to gain a theoretical understanding of the likely processes of behaviour change (Craig et al., 2008). Within health behaviour and promotion research the use of a socio-ecological model as a theoretical underpinning has been widely used since it was originally proposed (Elder et al., 2007; McLeroy, Bibeau, Steckler, & Glanz, 1988). Levels of influence within the socio-ecological model include: intrapersonal factors and processes, primary groups, institutional factors, community factors and public policy (McLeroy et al., 1988). The socio-ecological framework provides a comprehensive approach, allowing for the examination of multi-level factors when determining children's PA and identifying

opportunities to intervene and promote participation. Every school-aged child is surrounded by multiple levels of overlapping influences on their school PA behaviour (Carson et al., 2014). Furthermore, ecological models are well suited for studying PA because participation occurs in specific locations such as schools. Ecological models direct attention towards the characteristics of locations including the broader political and environmental factors which either facilitate or hinder participation (Sallis et al., 2006). School-based PA research has highlighted many factors that can influence implementation, which are important for future research to consider (Naylor et al., 2015). Given that various factors can be influential to implementation, the use of a multi-level socio-ecological framework to design school-based PA promotion strategies is further supported (Naylor et al., 2015). Application of a socio-ecological perspective allows for the design of PA interventions that acknowledge the interconnectedness between an individual and his or her environment (Carson et al., 2014). A review of the literature has indicated that interventions targeting PA determinants at different levels of the socio-ecological model including the social, organisational, and built environment levels have the highest potential to increase overall PA in youth (Kellou, Sandalinas, Copin, & Simon, 2014).

The Youth Physical Activity Promotion Model (YPAPM) adopts a social-ecological framework (Welk, 1999). Whilst the YPAPM is not a theory in itself, it aims to unite constructs from theoretical frameworks for example, behavioural change theories and the socio-ecological standpoint of acknowledging various personal, social, and environmental influences on children's PA (Welk, 1999). Thus, the YPAPM serves as a bridge between theory and practice (Welk, 1999). The YPAPM model is illustrated in

Figure 1.1. This model provides a broad perspective on the factors that influence PA behaviour in children, and links between these factors are also proposed. The use of the YPAPM is particularly useful to better understand population specific characteristics that require consideration prior to establishing a programme and relate to children only rather than adults too. Predisposing variables of influence increase the likelihood of regular participation and are reduced into two questions. Firstly, whether participation is worth it, addressing the benefits and costs and secondly, whether the individual is able, addressing perceived competence and self-efficacy. Enabling factors are variables that allow youth to be physically active, which are environmental such as access, and also biological such as skill. Reinforcing determinants come from the social/family category and are variables that reinforce a child's PA behaviour. Finally, personal demographics recognises the importance of individual differences including age, gender, ethnicity, culture, and SES.

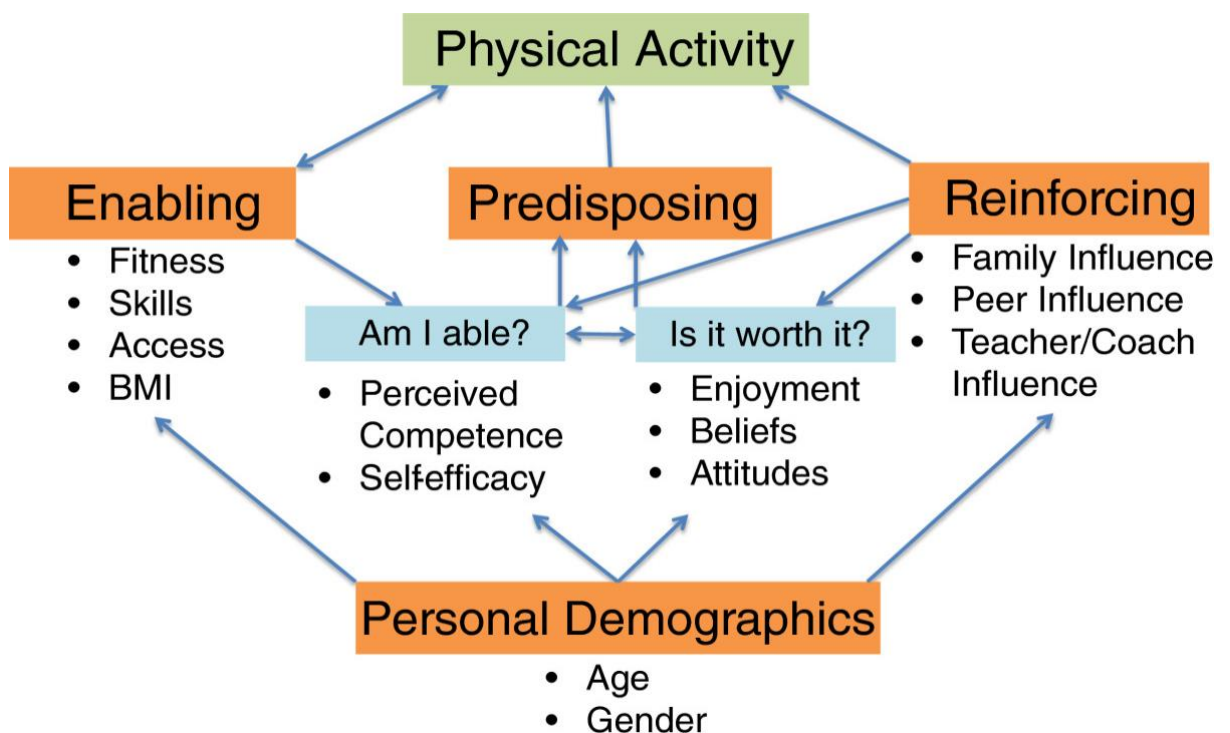


Figure 1.1. A conceptual diagram of the YPAPM (Welk, 1999).

Incorporating the YPAPM within a socio-ecological framework for the current programme of research will assist in establishing and intervening with the interactive characteristics of individuals and environments which underline their participation and are subsequently well suited for the design of multi-component interventions.

Previous school-based PA interventions have been based upon other theories such as Self Determination Theory and Social Cognitive Theory (Jago et al., 2013; Wilson et al., 2011). Therefore, it is important to consider whether these theories could also be useful for the design of the AS:Sk intervention. Self-Determination Theory proposes that behaviour changes which are motivated by intrinsic factors such as an activity being enjoyable, self-driven with a sense of choice and autonomy, and promote a sense of competence will be sustained and prolonged over time (Ryan & Deci, 2000). This theory is well suited to interventions with after-school components, such as the Bristol Girls Dance Project for example which implemented an after-school dance programme to increase PA among 11-12 year-old girls (Jago et al., 2013). Social-cognitive theory suggests that activity behaviours are influenced by the interaction between a person's attitude, the social norm, and surrounding influences (Welk, 1999). Whilst self-efficacy is a construct of importance within this theory so too are social systems (Bandura, 1996). When considering these two theories it was notable that many aspects are already considered within the YPAPM for example, enjoyment, perceived competence, self-efficacy, and social systems such as family and friends (Welk, 1999). The only factor which is not considered within the YPAPM, is autonomy and a sense of choice which is not of particular interest in a school-based PA intervention implemented within compulsory school hours in which children have

limited autonomy due to dictation from teachers for example. Therefore, because aspects of the Social-Cognitive Theory are already included within the YPAPM and Self-Determination Theory was not deemed relevant to AS:Sk, neither warranted inclusion.

The use of school-based multi-component interventions is advocated, but research has shown that they may not always be successful at increasing PA levels in CYP (Okely et al., 2017; Van Kann, Kremers, de Vries, de Vries, & Jansen, 2016). Multi-component interventions are difficult to put into practice and a lack of implementation with schools not implementing as intended, has previously been reported (Okely et al., 2017). Recently, a more pragmatic approach to PA promotion has been proposed which includes the expansion, extension, and enhancement of PA opportunities (Theory of Expanded, Extended, and Enhanced Opportunities; TEO) (Beets et al., 2016). Expansion includes the replacement of time allocated for low active or sedentary activities with time allocated for activities which are of a higher intensity, this could include physically active lessons instead of sedentary learning (Beets et al., 2016). Extension would be lengthening of time currently allocated for PA opportunities, for example longer PE or recess periods (Beets et al., 2016). Lastly, enhancement refers to modifications that could be made to existing PA opportunities to increase the amount of PA which accumulated within the given time period (Beets et al., 2016). The authors of TEO reinforce the importance of traditionally applied behavioural theories, stating that a focus on expanding, extending, and enhancing PA opportunities does not negate their importance (Beets et al., 2016). Hence, the use of the TEO approach within this thesis alongside the socio-ecological and YPAPM perspective, will allow for various levels of influence on children's PA to be targeted.

Additionally, and importantly, the TEO will lead to the identification of targets which are appropriate and attainable for schools to achieve as it is recommended that the three TEO mechanisms are considered alongside practicality and implementation (Beets et al., 2016). For example, expansion and extension provide additional time for PA which have associated practicality considerations such as whether school staff are willing to replace academic time for additional PA. Subsequently, if expansion and extension are not possible or if they are already included within a multi-component intervention which requires additional components or strategies during the design stage for example, enhancement of existing PA opportunities is then an option (Beets et al., 2016).

1.3 Aims and objectives

The main aim of this thesis is to explore intervention approaches to promoting primary school PA in a low SES community, which will ultimately result in the implementation of a multi-component intervention. These intervention strategies will be novel in their approach as they will be reliant upon existing school staff structures for implementation and will have no or limited financial cost to either the project or the participating schools. Resultantly, if the strategies are successful and feasible, it is proposed that they can be sustained by schools once the intervention period is over. Although the participating schools of the thesis will be based within a community of high deprivation, this will not influence the design, implementation and evaluation of the intervention studies. The high deprivation community selected for the thesis to recruit schools from was done so because of the known health inequalities and limited PA opportunities for children. It is envisaged that the school-based PA strategies will

be applicable to other primary schools regardless of whether they are based in an area of high or low deprivation.

Despite the main outcome for assessing success being children's PA levels, the thesis acknowledges the nature of school environments which are busy, unpredictable and diverse in nature. Therefore, it is essential that teacher perspectives are included throughout the thesis to better understand whether the strategies are feasible in practice. In addition to this, children's perspectives will be explored to better understand the acceptability of the strategies from the view point of those whom they target.

Four studies were conducted to address the following research questions:

Study 1

1. What are the current PA and ST levels of children aged 9-10 years who attend primary school in an area of high deprivation?
2. What are the child and school-level variables of influence on children's PA and ST levels during school segmented school hours?

Study 2

3. Are three school-selected, single-component school-based PA interventions deemed feasible and acceptable for use by the target population (teachers and children)?
4. Are three school-selected, single-component school-based PA interventions effective at positively impacting levels of school-based PA and ST?

Study 3

5. Is the AS:Sk multi-component intervention effective at positively impacting;
 - 5a. Levels of school-based PA?
 - 5b. Levels of school-based ST?
 - 5c. Health indicators?

Study 4

6. Was the AS:Sk multi-component intervention implemented as intended?
7. Was the AS:Sk multi-component intervention feasible and acceptable to implement and incorporate into everyday school life?

1.4 Organisation of Thesis

A review of current literature is provided in Chapter 2, with key topics covering children's PA and ST, measures of PA, the school environment and school-based PA interventions. Chapter 3 describes the general methods that were used across all of the thesis studies. Any additional study-specific methods are described in each relevant chapter. Chapter 4 (Study 1) is an investigative study into the levels of PA and ST during school hours in a sample of children from the low-income target community of the overall thesis, the town of Skelmersdale. Through the use of multilevel prediction analyses, child and school-level influences on these behaviours (PA and ST) are explored. Chapter 5 (Study 2) is a mixed-methods study which explores the acceptability and feasibility of different single component primary school PA interventions which were implemented for a four-week trial period in seven participating schools. Chapter 6 (Study 3) represents a development of the single component approach with the evaluation of a pilot multi-component school-based PA

clustered randomised controlled trial. Within this multi-component intervention, strategies deemed appropriate from Study 2 were combined with further multiple approaches within four intervention schools, whilst three school acted as the control comparison group. Finally, Chapter 7 (Study 4) is a process evaluation of the multi-component intervention presented in Chapter 6. This process evaluation draws upon various qualitative data sources to explore the implementation of the intervention within the participating schools. The final chapter (Chapter 8) will aim to synthesise the key findings of the thesis and discuss the overall strengths and limitations, with a conclusion for future research and practice recommendations.

1.5 Original contribution to knowledge

Original contributions to knowledge will be made through the design, pilot, implementation, and evaluation of PA interventions which are novel in their approach, because: (1) they will be reliant upon existing school staff structures for implementation; (2) they will have no or limited financial cost to either the project or the participating schools; and (3) they will be implemented in Skelmersdale, a high deprivation area of the West Lancashire borough which has not been previously been targeted by any school-based PA interventions before. Decisions throughout the programme of work will be informed by the socio-ecological framework (McLeroy et al., 1988), YPAPM (Welk, 1999), and TEO (Beets et al., 2016), therefore introducing a novel approach which considers the child, class, and whole-school in relation to school policies, physical environment and curriculum, whilst designing strategies which are appropriate and attainable for use within primary schools. Initially single component interventions will be specifically designed to target elements of the participating

schools' individual environments which are most in need of PA intervention. This will lead to the implementation and evaluation of a school-based multiple component intervention to enhance children's PA that is based on formative work. Children will be recruited via passive consent which will significantly reduce researcher and teacher burden and provide an example of how this approach to consent is feasible in school-based research in the UK. Only a limited number of previous school-based PA studies have used passive consent. PA will be assessed using device-based measures and a novel approach to accelerometer data utilising raw acceleration outcomes. It is believed that this will strengthen outcome accuracy. Qualitative data from the target population (teachers and children) will complement the quantitative PA data to provide mixed-methods robust evidence on effectiveness, feasibility and acceptability.

Chapter 2: Literature Review

2.1 Physical Activity Guidelines

PA can be classified and measured by the intensity of effort required, ranging from light PA (LPA), moderate PA (MPA) and vigorous PA (VPA) (Butte, Ekelund, & Westerterp, 2012). Examples of light activity include: moving around the house and walking slowly between school lessons or while shopping (Chief Medical Officer Department of Health, 2011). Moderate intensity activities will make a person feel warmer, breathe harder, or their heart beat faster while still being able to converse, for example playground activities (The Health and Social Care Information Centre, 2012). Whilst the effects of vigorous activities are similar to that of moderate activities, it makes conversation much harder, for example, fast running or swimming (The Health and Social Care Information Centre, 2012).

It is MVPA which national Government recommendations refer to, from countries such as Australia, UK, Netherlands, Canada, and USA, stating that CYP should engage in 60 minutes of MVPA daily (Australian Government, 2017; Chief Medical Officer Department of Health, 2011; Health Council of the Netherlands, 2017; Tremblay, Carson, et al., 2016; U.S. Department of Health and Human Services, 2008a). It is also recommended that VPA and bone strengthening activities are incorporated to at least three days per week (Australian Government, 2017; Chief Medical Officer Department of Health, 2011; Health Council of the Netherlands, 2017; Tremblay, Carson, et al., 2016; U.S. Department of Health and Human Services, 2008a). In comparison to the guidelines for PA, recommendations for ST are less prescriptive and specific, although efforts to reduce overall ST and minimise extended periods spent sedentary across the whole day are advocated in various national recommendations (Chief Medical

Officer Department of Health, 2011; Health Council of the Netherlands, 2017; Tremblay, Carson, et al., 2016).

2.2 The Health Benefits of Physical Activity Participation

Systematic reviews have highlighted the importance of PA participation during childhood with results suggesting that PA is associated with numerous health benefits in school-aged children and youth (Janssen & LeBlanc, 2010; Poitras et al., 2016). Favourable relationships are evident between PA and health indicators including adiposity, cardiometabolic markers such as cholesterol and blood pressure, physical fitness, bone health, and cardiovascular disease risk factors (Andersen, Riddoch, Kriemler, & Hills, 2011; Poitras et al., 2016). Research has further explored health benefits in relation to PA intensities (i.e., LPA, MPA, MVPA, and VPA). LPA participation for example has mixed outcomes. Evidence has suggested that LPA participation does have favourable associations with cardiometabolic markers in adolescents (Carson et al., 2013). Conversely, other studies have found that LPA participation has no beneficial associations with cardiometabolic markers or cardiorespiratory fitness (CRF) and that only vigorous intensity has significant correlations with these outcomes (Aires et al., 2010; Hay et al., 2012).

Evidence indicates that better fitness and health outcomes are observed when children and young people engage in 60 minutes of MVPA of various types throughout the day (U.S. Department of Health and Human Services, 2008b). Overall, evidence suggests that of greatest interest to child health is MVPA because of its more consistent association with health outcomes and larger effect sizes when compared to lower intensity PA (Ekelund et al., 2012; Saunders et al., 2016). This underlines the

importance of current guidelines of 60 minutes of MVPA per day. Meeting MVPA guidelines results in children exhibiting lower cardiometabolic disease risk (Boddy et al., 2014). Furthermore, the analysis of a large data pool (over 20 thousand; aged 4-18 years) showed higher MVPA time was associated with better established cardiometabolic outcomes of waist circumference, systolic blood pressure, fasting triglycerides, high-density lipoprotein cholesterol, and insulin (Ekelund et al., 2012). Isotemporal substitution analysis, studying the effects of displacing one specific type of activity with another in an equal amount of time, has also highlighted the importance of MVPA for the health of CYP (Huang, Wong, He, & Salmon, 2016). In a study of children with an average age of 7.6 years, reallocating 30 minutes of MVPA per day with sedentary behaviours (SB) resulted in increased body mass index (BMI) (Huang et al., 2016). Compositional analysis is a more novel approach which has recently arose in the literature to better understand the impact of different PA intensities on indicators of health (Dumuid et al., 2018; Fairclough et al., 2017; Talarico & Janssen, 2018). Consistent with isotemporal substitution analysis, this methodology explores the effects of reallocating time between intensities on health outcomes. However, compositional analysis conceptualises the daily activity of individuals as compositions, meaning that time spent in sleep, SB, LPA, and MVPA cannot occur simultaneously and their occurrence is constrained by the 24 hours of a day (Dumuid et al., 2018). The replacement of MVPA with any other movement behaviour has predicted higher adiposity, body fat percentage, and lower CRF (Dumuid et al., 2018; Fairclough et al., 2017).

The benefits which participation in PA can have for CYP is evident across many aspects of health, not just physical. For example, improved self-perceptions and enhanced self-esteem in young people from PA participation were established in a systematic review of the literature (Lubans et al., 2016). There is also evidence to suggest that PA can have beneficial effects on cognitive development (Carson et al., 2016), cognitive performance (Mura, Vellante, Nardi, Machado, & Carta, 2015), academic achievement (Álvarez-Bueno et al., 2017), and improved mental health (Ahn & Fedewa, 2011).

2.3 Physical Activity Levels

Worldwide objective data have revealed that 80% of 13–15 year olds do not meet the 60 minutes of MVPA per day guidelines (Hallal et al., 2012). Further worldwide data also revealed a high prevalence of inactivity amongst 11-17 year olds (Sallis et al., 2016). Among this data from 2016, 78% of boys and 84% of girls were insufficiently active (Sallis et al., 2016). Objectively measured PA from the International Children's Accelerometry Database (ICAD) consisting of data from more than 20,000 participants from 10 countries aged two to 18 years, showed that boys were more active than girls and the recommended 60 minutes of MVPA was accumulated on 46% of all measured days for boys and 22% for girls (Cooper et al., 2015). Also, after age five, there was a 4.2% decrease in total PA with each additional year of age (Cooper et al., 2015).

The development and release of global report cards on the PA of children and youth has proved useful in recent years to allow for comparisons to be made across countries (Tremblay, Barnes, et al., 2016). England's 2016 report card on the PA levels of children and youth established overall PA levels as a grade D- (Wilkie et al., 2016). This grade was based on results that showed boys and girls to consistently be within

the 0-40% bracket of percentage meeting guidelines (Wilkie et al., 2016). The grade is a decline in comparison to the 2014 report, in which a grade of C/D was awarded (21-60% meeting guidelines) (Standage et al., 2014). These findings were comparable to those from the 2016 report card results for Australia and the U.S. for overall PA, which were D- (Katzmarzyk et al., 2016; Schranz et al., 2016). Though useful as a barometer of activity levels, the validity and reliability of the report card methodology requires improvement through the use of harmonised measures, including objective measures of PA, on larger, more representative samples (Tremblay, Barnes, et al., 2016).

Health Survey for England self-report data in 2015 indicated that 23% of boys aged 5 to 15 years in England met the PA guidelines, which was higher than the proportion of girls (20%) (National Statistics, 2017b). Values have been stable (2012; boys 21%, girls 20%) but for boys only, recent figures are significantly lower in comparison to 2008 (boys 28%; girls 19%) (National Statistics, 2017b). Objectively assessed PA data from a large (>6,000) UK cohort also established that there is a gender gap (Griffiths et al., 2013). Only half of seven year old children in the UK achieved the recommended levels of PA, and for girls this was significantly lower (38%) compared to boys (63%) (Griffiths et al., 2013). Further accelerometry data from a UK cohort showed that time spent in MVPA per day reduced from ages five to six (boys, 72 minutes; girls, 62 minutes) to ages eight to nine (boys, 69 minutes; girls, 56 minutes) (Jago et al., 2017).

2.4 Sedentary Time

There are great incentives for increasing PA levels in CYP given the established health benefits and the apparent low levels of activity which children currently accrue. In addition, there is growing concern and attention being paid to engagement in ST and

the detrimental effects which this can have on the health of CYP (Biddle, García Bengoechea, & Wiesner, 2017; Carson, Hunter, Kuzik, Gray, et al., 2016). Furthermore, it is important that time spent sedentary and time spent being physically active are considered as independent constructs (Pate, Mitchell, Byun, & Dowda, 2011). Any waking behaviour characterised by an energy expenditure of 1.5 METs or less, when in a sitting, reclining or lying posture is classified as sedentary (Tremblay et al., 2017). This behaviour has become a common aspect of the daily lives of most adults and children alike due to the dependence on cars and trends in electronic entertainment, such as screen-based media (Salmon, Tremblay, Marshall, & Hume, 2011).

There is research which has argued that children should be encouraged to increase participation in MVPA rather than reducing overall ST (Ekelund et al., 2012). This is because time spent sedentary was found to be unrelated to cardiometabolic risk factors after adjusting for time spent in MVPA (Ekelund et al., 2012). Time spent in MVPA was associated with such risk factors independent of time spent sedentary (Ekelund et al., 2012). That being said, there is a body of research which suggests that ST should be limited in CYP due to the detrimental effect it can have on other health outcomes.

Longitudinal research has found that independent of MVPA, an increase in ST across childhood and adolescence is associated with an increase in body fatness (Mann et al., 2017). In a European study of adolescents, those with high cardiorespiratory fitness spent less time sedentary (Ruiz et al., 2011). Overall ST can include a range of specific surrogate SB which most commonly includes, desk-based work (reading, completing school homework) or sitting while socialising (Pate et al., 2011; Pate, O'Neill, & Lobelo,

2008). Screen-based behaviours are also a major contribution to overall ST, such as television watching, recreational computer use, watching DVDs/videos and playing video games, as well as smartphone and tablet use (Saunders & Vallance, 2017). These SB have been studied independently to better understand the influence on child health. Engagement in SB such as screen time and television viewing have been shown to be detrimental to many aspects of health such as body composition, CRF, metabolic syndrome, and cardiovascular disease risk factors (Carson et al., 2016). Furthermore, greater television and computer use in particular has been shown to be related with greater psychological difficulties in children, irrespective of MPVA levels or overall ST (Page, Cooper, Griew, & Jago, 2010). The likelihood of having risk factors which predispose premature mortality (metabolic syndrome) increased as daily screen time (television, video and computer game use) increased, among a sample of Canadian children (Mark & Janssen, 2008).

European objectively measured data indicate that primary school children spend 55% of their time in SB (Spittaels et al., 2012). World-wide accelerometer data have also revealed that ST progressively increases after age five to six (Cooper et al., 2015). Self-reported data similarly indicated that the ST of children in the UK progressively increases with age (National Statistics, 2016). In the UK, 9% of children are sedentary for six hours or more per day on weekdays, and this increases to 19% of children on weekend days (National Statistics, 2016). Also within the UK, parental interview data revealed that between Year 1 (5-6 years) and Year 4 (8-9 years) of primary school, screen-viewing interests change and parents' ability to manage screen-viewing becomes harder (Jago et al., 2018).

2.5 Physical Activity Measurement

In order to be able to establish accurate PA levels and ST in children it is important that accurate measurements are used. The Behavioural Epidemiology Framework which classifies sequences of research categories for health-related behaviours, includes the development of methods for measuring behaviour as a key category (Sallis, Owen, & Fotheringham, 2000). Accurate measurement is also important within the various other important PA research topics. For example, when establishing links between PA and health, identifying factors that influence PA, and for evaluating interventions which aim to change PA behaviours (Sallis, Owen, et al., 2000). Key elements of any measurement is that they are reliable, PA and ST should be classified in the same way on repeat administration, and valid, assessing what the measure intended to (Bauman, Phongsavan, Schoeppe, & Owen, 2006). Self-reported measures of PA are commonly used because of their simplicity and ability to provide type and context of activities in large samples (Rowlands & Eston, 2007). However, limitations associated with self-reported questionnaires include individual interpretation of questions, reliance on recall, and social desirability effects (Loprinzi & Cardinal, 2011). Also, for studies involving younger children (10 years or younger) objective measures are recommended as the validity of self-reported measures is lower for children compared to adolescents (Loprinzi & Cardinal, 2011).

Accelerometers have been deemed a valid and reliable method for use in quantifying children's PA levels (Ekelund et al., 2001). Accelerometers are a popular method of choice for researchers, and since 2005 the number of studies using accelerometers with children and adolescents has grown rapidly (Cain, Sallis, Conway, Van Dyck, &

Calhoun, 2013). Accelerometers are small and lightweight monitors which record the frequency and magnitude of the body's acceleration during movement allowing for intensity to be studied (Loprinzi & Cardinal, 2011).

Accelerometers have been traditionally worn on the hip as research established that this location was most accurate for estimations of energy expenditure and activity intensity (Rosenberger et al., 2013). Increasingly, devices are being designed to be worn on the wrist to promote better wear compliance (Fairclough, Noonan, et al., 2016). Accelerometer wear is important when this method is being used, as better compliance allows researchers to have greater confidence that the data collected are representative of actual PA (Fairclough, Noonan, et al., 2016). Children have shown high compliance with wrist worn monitors (>90% in a study of nearly 900 participants aged 9-10 with a minimum wear time inclusion of 10 hours for three week days and one weekend day) (Price et al., 2018). In a study comparing compliance of hip and wrist worn monitors, more children aged 9-10 wore the wrist than hip, irrespective of wear time inclusion criteria applied (Fairclough, Noonan, et al., 2016). Recent recommendations also suggest utilising a 24-hour protocol in which children are asked to only remove devices for water-based activities to improve compliance. For example, an average wear time of 22.6 hours was observed in a study of 9-11 year olds, and this was with hip worn monitors (Tudor-Locke et al., 2015).

Irrespective of which accelerometry-based device is used (many models are available), count data are the most common output (Rowlands, 2007). These accelerometer count outputs are then translated into a measure of MET expenditure to establish cut-points, which allows for PA intensity to be established (Masse et al., 2005; Trost,

Loprinzi, Moore, & Pfeiffer, 2011). Various intensity-related cut-points for children and adolescents have been published. A study by Trost and colleagues aimed to evaluate the classification accuracy of five sets of independently developed ActiGraph cut points using energy expenditure, measured by indirect calorimetry (Trost et al., 2011). This study concluded that 'Evanson' cut-points should be used in order to achieve an acceptable classification accuracy for all four levels of PA intensity (Trost et al., 2011). Despite this, cut points are population and protocol specific so there is limited consensus on cut-point values which are most acceptable for estimating time spent sedentary and in MVPA, which has significantly hindered progress in youth PA behaviour research (Fischer, Yildirim, Salmon, & Chinapaw, 2012; Gába, Dygrýn, Mitáš, Jakubec, & Frömel, 2016; Trost et al., 2011). Research has confirmed that study findings highly depend on the selected cut-points (Pedišić & Bauman, 2015). For example, the mean levels of MVPA from the same data set of children aged 7-12 years significantly differed depending on the cut-points selected (Gába et al., 2016). Using five established cut-points, mean MVPA minutes per day ranged from 27 to 231 minutes (Gába et al., 2016). A move away from cut-points has been advocated with novel approaches, such using the *intensity gradient* which capture intensity distribution alongside average acceleration or overall activity, proposed (Rowlands, Edwardson, et al., 2018). This approach is also not reliant on calibration protocols, which are highly dependent on the population and protocol used (Rowlands, Edwardson, et al., 2018).

A further limitation of count data is that they are the result of internal processes such as filtering and scaling which leads to different device dependent outputs that

therefore cannot be directly compared (Welk, McClain, & Ainsworth, 2012). Best practice recommendations have proposed that monitor data should be collected and saved as raw signals to avoid the uncertainty of pre-processed data such as counts and the possibility that filtration methods can drastically alter the results of a study (Freedson, Bowles, Troiano, & Haskell, 2012; Peach, Van Hoomissen, & Callender, 2014). Recently there has been an advance in the literature surrounding activity data with the move toward raw acceleration signal processing. Raw acceleration data has been used within adult and child PA research and also calibration research (de Almeida Mendes et al., 2018; Fairclough et al., 2016; Noonan, Boddy, Kim, Knowles, & Fairclough, 2017). The use of raw data gives an increased control over data processing as well as the opportunity to improve comparability and consistency between studies which use different devices for example (Hildebrand, Van Hees, Hansen, & Ekelund, 2014).

2.6 Correlates of Physical Activity

After the development of methods for measuring behaviour, the next stage of the Behavioural Epidemiology Framework on health promotion is to identify factors that influence behaviour (Sallis, Owen, et al., 2000). Correlates research for example provides evidence about factors which are associated with PA participation (Bauman et al., 2012). This research can help to evidence how behaviour varies by sex, age, ethnic group, SES, and others, thus identifying characteristics or groups of people who are most in need of intervention (Sallis, Owen, et al., 2000). It is important to understand the factors which influence participation to plan and develop effective PA interventions in CYP (Bauman et al., 2012; Sallis, Prochaska, & Taylor, 2000). However,

correlates do not infer causality and the cross-sectional nature of correlational studies highlights a limitation of the research (Bauman, Sallis, Dzewaltowski, & Owen, 2002).

PA is complex and its occurrence varies within different domains (e.g., at home, at work/school, in transport, and in leisure time), with correlates representing not only individual factors but several further levels of influence (Bauman et al., 2012). The socio-ecological model reflects this with the inclusion of various levels of variables that are expected to influence behaviour, such as intrapersonal (biological, psychological), interpersonal/cultural, organisational, physical environment (built, natural), and policy (laws, rules, regulations) (McLeroy et al., 1988). A recent review of literature revealed a number of correlates that were consistently associated with PA in children and/or adolescents including sex, age, ethnicity, parental support, enjoyment, perceived competence, and perceived barriers (Best, Ball, Zarnowiecki, Stanley, & Dollman, 2017; Sterdt, Liersch, & Walter, 2013). The research area has also attempted to determine correlates associated with meeting the MVPA guidelines. Results indicate that girls, overweight/obese children, those who accumulate more screen time, and earlier maturing children were all less likely to comply with MVPA guidelines (Gomes et al., 2017). Further significant positive relationships with meeting MVPA guidelines have been reported with self-efficacy, sport participation, active transport, parental support, and outdoor time after school (Wilkie, Standage, Gillison, Cumming, & Katzmarzyk, 2018).

2.7 Socio-economic Status and Deprivation

In addition to the correlates mentioned in the previous section, a specific correlate of PA which is important for this thesis is SES. SES is a construct encompassing individual,

household, and/or community access to resources (Psaki et al., 2014). It is commonly conceptualised as a combination of economic, social, and work status, measured by income or wealth, education, and occupation (Psaki et al., 2014). Thus, the individual SES of child participants most commonly refers to a quantification of family income, parental education level and parental occupational status (Bradley & Corwyn, 2002). Conversely, deprivation, which is commonly used in relation to whole communities or areas — ‘deprived community’, reflects a lack of economic resources (Harris & White, 2013).

Research has shown that the socio-economic conditions experienced during childhood can shape all-cause mortality and overall health-related burden in middle and late adulthood (Turrell, Lynch, Leite, Raghunathan, & Kaplan, 2007). A systematic review found 22 studies that have reported a lower childhood socio-economic position to be associated with less frequent adult leisure time PA (Elhakeem, Cooper, Bann, & Hardy, 2015). Furthermore, health inequalities occur before adulthood, as childhood obesity prevalence shows a strong association with living in deprived areas of the country (Copley & Bray, 2017). The prevalence of obesity amongst children living in the most deprived areas of England is more than double that of peers living in the least deprived areas according to the National Child Measurement Programme (NCMP) (National Statistics, 2017a). The 2016/17 NCMP found obesity among Year 6 children (ages 10-11) living in the most deprived areas was 26% compared with 11% among those living in the least deprived areas (National Statistics, 2017a). This deprivation gap has also increased over time (National Statistics, 2017a).

Evidence relating to SES and the PA of children is mixed, as is the way in which SES can be measured. Lower SES home environments typically provide more opportunities for ST and fewer for PA. For example, the Neighbourhood Impact on Kids study found that lower SES (indicated by the highest level of reported education of the parent(s) in the household and household income) parents watched TV/DVDs with their children more often than higher SES parents (Tandon et al., 2012). The same study also found greater access to electronic media devices in the bedrooms of lower SES children with increased restriction regarding their outdoor play (Tandon et al., 2012). Further research has demonstrated SES indicators (parental education, parental income, parental occupation, eligibility for free school meals, car/house ownership, neighbourhood income level, type of school – private/state) to be inversely related to the presence of a TV in the child's bedroom (Gebremariam et al., 2015). It has also been reported that high SES children perceive PA participation to be of greater importance than comparable low SES children (participation in subsidised school education material and meal programme used as a proxy for SES) (Seabra et al., 2013). This can be explained by the more positive attitudes towards the value of PA and healthy lifestyles which older or other family members from higher social classes generally have, which are subsequently transferred to children (Seabra et al., 2013). Through the use of household income as an indicator of SES, and pedometer (steps/day) to assess free-living PA, a study showed lower PA levels and more ST within low SES children (Drenowatz et al., 2010). Although the authors noted that these differences in PA levels were influenced by BMI (Drenowatz et al., 2010). Conversely, at the area level of a UK study, more PA was associated with higher deprivation (Pouliou et al., 2015). Also, lower total accelerometer-measured ST was

linked with low socio-economic position (a combination of family income and occupational status with area level deprivation) in a study of children aged 5-15 (Coombs, Shelton, Rowlands, & Stamatakis, 2013).

Behavioural choices are facilitated or constrained by wider aspects of a child's social and physical environment (Kirby, Levin, & Inchley, 2013). Having a private garden for example, has been shown to be associated with significantly lower levels of ST after school and on weekend days (Pulsford, Griew, Page, Cooper, & Hillsdon, 2013). Within a child's wider neighbourhood environment, it has been reported that favourable social environments such as social cohesion, closeness, common values, trust and helpfulness at the community level are positively related to PA (Franzini et al., 2009). Conversely, the unfavourable social factors of crime, safety, and neighbourhood social disorder are negatively associated with children's PA (Davison & Lawson, 2006; Kneeshaw-Price et al., 2015; Molnar, Gortmaker, Bull, & Buka, 2004). Parents who perceived that it was safe for their child to play outside their house subsequently reported more regular outdoor play on both weekdays and weekend days by their child (Veitch, Salmon, & Ball, 2010). Parental concerns about strangers and fast drivers were also inversely associated with duration of play on a weekday (Faulkner, Mitra, Buliung, Fusco, & Stone, 2015). It should be noted that research is predominantly North American or Australian, although parents from deprived areas of a UK city named Coventry, have also stated that crime and anti-social behaviour influence children's PA behaviour and results in greater indoor sedentary activities (Eyre et al., 2014). This was supported by a study in the most deprived areas of another UK city named Liverpool, in which parental reported safety concerns was consistent with

access to bedroom media equipment (Noonan, Boddy, Knowles, & Fairclough, 2016). Overall, outdoor play is important as a linear relationship with MVPA has been established (Faulkner et al., 2015).

Regarding the physical neighbourhood environment, both the provision and accessibility to recreational spaces such as public parks, playgrounds, playing fields, as well as sports facilities are limited within lower SES areas (Eyre, Duncan, Birch, Cox, & Blackett, 2015; Eyre et al., 2014; Kirby et al., 2013). Although urban regeneration interventions aim to change this, for example the London 2012 Olympic and Paralympic Games lead to urban regeneration (e.g. improvement in facilities, services, built infrastructure) of London boroughs significantly more disadvantaged than the London average (Smith et al., 2012). The exposure to, and accessibility or proximity of green spaces and other recreation facilities are associated with PA among CYP (Ding, Sallis, Kerr, Lee, & Rosenberg, 2011; Ward, Duncan, Jarden, & Stewart, 2016). The PA levels of Swiss children aged 7-9 years located in low and high SES areas of Zurich were studied to investigate whether locations of PA engagement differed (Bürgi, Tomatis, Murer, & de Bruin, 2016). The study found children from high-SES neighbourhoods recorded significantly more MVPA in parks and sports facilities, although when considering the total time spent at these settings the proportion of time spent in MVPA whilst there were similar across SES groups (Bürgi et al., 2016). It was proposed that the difference in overall MVPA at these settings could be due to a more frequent use as opposed to different behaviours occurring within the settings (Bürgi et al., 2016). This assumption was supported by a higher density of parks in the high-SES district (Bürgi et al., 2016).

The urban design of a child's physical environment also appears to be influential. For example, pedestrian safety structures such as traffic lights, walking facilities such as pavements, street connectivity and residential density have all been associated with reported PA in children (Ding et al., 2011). If favourable, such aspects of urban design provide children with better opportunities to participate in active transport and leisure-time PA (Ding et al., 2011).

The role of a child's SES in relation to PA participation is important and relevance to the current thesis due to the location of participating schools. The town of Skelmersdale is situated in the West Lancashire borough of North-West England. The ethnicity of residents in West Lancashire is almost entirely White British (98%), which is higher than the percentage for England overall (National Statistics, 2012). More specifically, within Skelmersdale, 5% of the population are White Other which is thought to reflect the Eastern European community who live and work in the area (National Statistics, 2012). Skelmersdale contains seven of the most deprived districts not only within the West Lancashire borough, but the whole of Lancashire and England (Collins, 2015). The proportion of work age residents claiming job seekers allowance is a measure of unemployment, and Skelmersdale has the highest level of claimants in West Lancashire (almost 1,300 claimants) (West Lancashire Borough Council, 2014). Figures indicate that the seven Skelmersdale districts all have the highest proportion of children living in poverty within West Lancashire and looking to later life, six of the seven districts have all-cause premature mortality rates significantly above the England national average (Collins, 2015). Trend data have showed that across the school years 2014-2015 to 2016-2017, 36.2% of Year 6 children (10-11 years) living in

the areas of Skelmersdale North and Skelmersdale South were classified as carrying excess weight (34.3% nationally), with 21.7% classified as obese (20% nationally) (National Statistics, 2017a). These obesity related inequalities are therefore most relevant to the AS:Sk study, due to the figures within Skelmersdale which are above national averages.

2.8 School Environment

As discussed within the previous correlates sections of this literature review, there are an array of factors within a child's life which can influence and shape activity behaviours, schools have been identified as key environments of opportunity to promote PA regardless of children's individual life circumstances (Naylor & McKay, 2009). The full socio-economic spectrum of the population can be reached through the school environment (Craike, Wiesner, Hilland, & Bengoechea, 2018; Fox, Cooper, & McKenna, 2004). Furthermore, because most children and adolescents spend the majority of waking day hours in school, there are many potential opportunities for daily activity and PA interventions have become increasingly common within the school environment (Burns, Fu, & Podlog, 2017; Jones et al., 2010).

Research has indicated that the greatest accumulation of MVPA occurs within the school period of weekdays (Strugnell et al., 2016) and the school period can contribute to over 56% of children's total daily MVPA (Fairclough, Butcher, & Stratton, 2008). Examples of school-based opportunities which children are provided with to engage in PA include daily recess and PE lessons. Investigations have indicated that PA during school recess can contribute towards up to 40% of a child's recommended daily PA (24 minutes) (Ridgers, Stratton, & Fairclough, 2006), but a systematic review of the

contribution of school recess to daily PA concluded that the contribution was small, with 12 minutes of MVPA per school per day (Reilly, Johnston, McIntosh, & Martin, 2016). PE has been shown to play a substantial role in providing PA for children as they are more active in and out of school on days with PE than without (Meyer et al., 2013; Silva et al., 2018). Other school-based opportunities for PA engagement exist, such as active commuting (Chillon et al., 2010), classroom-based activity (Martin & Murtagh, 2017b; Watson, Timperio, Brown, Best, & Hesketh, 2017), as well as before school and after school hours (Beighle & Moore, 2012). However, crowded school curricular which have an intense focus on academic achievement can mean that time allocated for PE and overall PA participation is increasingly limited in schools (Hills, Dengel, & Lubans, 2015).

Furthermore, children engage in both non-recreational (schoolwork) and recreational ST within school (Committee on Physical Activity and Physical Education in the School Environment, 2013) which can account for 65% of their time at school (van Stralen et al., 2014). In a study comparing school time with non-school time on weekdays, children accumulated more sedentary time at school and spent more time in sustained sedentary sequences at school (Abbott, Straker, & Mathiassen, 2013).

More recently, the importance of the school environment for child PA engagement has been highlighted in PA guideline documents. The Institute of Medicine's Committee on PA in the school environment recommend that more than half of the recommended 60 minutes of MVPA should be accomplished during school hours (Committee on Physical Activity and Physical Education in the School Environment et al., 2013). The UK Government also made reference to school-based PA guidelines for

the first time in 2016, stating that at least 30 minutes of MVPA should be delivered in school through active break times, PE, extra-curricular clubs, active lessons, or other sport and PA events (HM Government, 2016).

2.9 School-Based Physical Activity Interventions

The growing evidence base surrounding the positive effects which school-based PA interventions and initiatives can have for child health has meant that their implementation is also becoming more common (Shah et al., 2017). A large review of 44 studies that evaluated the impact of school-based interventions focused on increasing PA among more than 36 thousand children and adolescents, found that an increase in duration of PA ranged from five to 45 more minutes per day (Dobbins, De Corby, Robeson, Husson, & Tirilis, 2009).

Examples of more specific targeted areas of the school day by interventions include, recess, PE, and classroom time. A number of strategies to enhance recess activity levels have been explored in the literature (Erwin, Ickes, Ahn, & Fedewa, 2014), and reviews of the literature have indicated effectiveness for increasing student PA during recess (Erwin et al., 2014; Ickes, Erwin, & Beighle, 2013). For example, providing extra equipment has been shown to significantly increase children's MPA from 38 to 50%, and VPA from 10 to 11% during lunch breaks (Verstraete, Cardon, De Clercq, & De Bourdeaudhuij, 2006); playground markings resulting in intervention school children engaging in 4.5% and 2.3% more MVPA and VPA respectively during recess than control school children (Ridgers, Stratton, Fairclough, & Twisk, 2007); playground active games which when implemented, VPA has been shown to be 52% higher compared to control schools (Beyler, Bleeker, James-Burdumy, Fortson, & Benjamin,

2014; Chin & Ludwig, 2013); and teacher and staff involvement/training results of which have demonstrated increases of 2.5 minutes of MPA and 2.2 minutes of VPA at recess (Huberty et al., 2011). However, considerations of costing and sustainability are needed with such interventions, for example with expensive playground equipment and the use of external coaches to implement active games.

Interventions targeting PE have focused on enhancing and increasing MVPA in lesson time allocated mainly through changes to teaching strategies through professional learning (McKenzie, Sallis, Rosengard, & Ballard, 2016; Powell, Woodfield, & Nevill, 2016; Verstraete, Cardon, De Clercq, & De Bourdeaudhuij, 2007), and fitness infusion (Bulger, Mohr, Carson, & Wiegand, 2001; Fairclough, McGrane, et al., 2016). A systematic review of the literature concluded that these intervention strategies are effective at increasing active learning time during PE (Lonsdale et al., 2013). Although it is important to remember that a balance within PE is needed between the amount of activity accrued and also the less active development of skills through instruction, feedback and reflection (Lonsdale et al., 2013).

Previously it has been claimed that few school-based studies have focused on increasing PA in the classroom (Erwin, Fedewa, Beighle, & Ahn, 2012). There is however an increasing number of school-based studies which have implemented active classroom breaks (ABs) (McMullen, Kulinna, & Cothran, 2014; Watson, Timperio, Brown, & Hesketh, 2017; Whitt-Glover, Ham, & Yancey, 2011) and the integration of PA with academic content (Martin & Murtagh, 2017a; Riley et al., 2017; Routen et al., 2017). These classroom-based intervention strategies have had positive effects on academic-related outcomes such as improved behaviour and academic

attainment (Daly-Smith et al., 2018; Martin & Murtagh, 2017b; Watson, Timperio, Brown, Best, et al., 2017). Positive effects on PA from classroom-based strategies are also evident (Daly-Smith et al., 2018; Martin & Murtagh, 2017b). For example, an intervention which integrated PA into mathematics lessons successfully increased MVPA levels and reduced ST within the school day (Riley, Lubans, Morgan, & Young, 2015). In a study of six schools, minutes/day of ABs was positively associated with students' MVPA, and students were more likely to achieve the recommended 30minutes/day of MVPA during school hours if their teachers reported implementing ABs (Carlson et al., 2015).

Whilst these interventions which target one area of the school day have potential for positively impacting children's MVPA levels, whole-school/multi-component approaches are advocated as a means of engineering a range of PA opportunities into the day using a variety of strategies across different school settings (Committee on Physical Activity and Physical Education in the School Environment et al., 2013; Fox et al., 2004). A comprehensive intervention perspective with a focus on multiple-level factors exemplifies a socio-ecological approach (McLeroy et al., 1988). Ecological models are well suited for the design of school-based interventions as they direct attention towards the characteristics of locations in which PA takes place. Within schools this can include the broader political and environmental factors which either facilitate or hinder participation (Sallis et al., 2006). The implementation of a CSPAP design has resulted in positive effects on PA (Brusseu, Hannon, & Burns, 2016; Burns, Brusseu, & Hannon, 2015).

Action Schools! BC is an ongoing example of an effective multi-component intervention consistent with the concept of a whole-school approach (Naylor, Macdonald, Reed, & McKay, 2006). An important aspect of this intervention was that programmes were customised based on the perceived needs of the schools and included activities across six action zones of: school environment, scheduled PE, classroom action, family and community, extra-curricular, and school spirit (Naylor, Macdonald, Warburton, Reed, & McKay, 2008; Naylor, Macdonald, Zebedee, Reed, & McKay, 2006). The ultimate goal was to provide students with 150 minutes of MPA per week (Naylor, Macdonald, Zebedee, et al., 2006). Teachers were trained and provided with resources to implement classroom activities, existing PE curriculum was supported, and additional PA opportunities were provided during the school day (Naylor, Macdonald, Zebedee, et al., 2006). The intervention led to schools providing approximately 10 extra minutes of PA per day and teachers were able to successfully implement the intervention through the resources, training and support received (Naylor, Macdonald, Zebedee, et al., 2006).

"Kinder-Sportstudie" (KISS) was a school-based programme implemented throughout one school year across 15 schools in Switzerland with seven PA components (Zahner et al., 2006). These components included: daily PE classes (two additional lessons to those already existent), classroom ABs, PA homework, adapted playground area to encourage PA, active commuting promoted and encouraged, family PA encouraged, decreased media time encouraged (Zahner et al., 2006). Changes in MVPA from baseline to follow-up were significantly higher in the intervention group compared to control group, corresponding to 13 additional minutes of MVPA within intervention

schools (Kriemler et al., 2010). Significant favourable changes in body composition and aerobic fitness were also observed (Kriemler et al., 2010). Authors recognised that the daily PE and classroom AB components of the intervention were almost entirely responsible for positive changes in PA (Kriemler et al., 2010). Whilst short 2-5 minute breaks during academic lessons may be feasible in other schools, five PE lessons per week is a time consuming strategy for increasing school-based PA, particularly when schools prioritise academic achievement in what is an already crowded curriculum.

Finnish Schools on the Move is an example of a national programme with significant government funding (multi-million) which aims to establish a physically active culture within schools by promoting PA and decreasing excessive sitting time through multiple strategies which schools can plan themselves (Blom, Tammelin, Laine, & Tolonen, 2017). Schools were not required to implement every strategy put forward by the programme. Example strategies which they were able to choose from included, development of school yards, facilities and equipment to enable PA, clubs before and after school, organised recess activities, longer recess period, PA breaks during academic lessons, student participation in a school PA working group, staff education and training (Blom et al., 2017). In a sample of four programme schools and two control schools, school day MVPA increased and ST decreased in programme schools however this did not translate into positive effects across the whole day in which time outside of school was also considered (Haapala et al., 2017).

Although targeting adolescents, “PA 4 Everyone” implemented seven PA strategies in schools located in areas of New South Wales, Australia that had low indices of SES (Sutherland et al., 2013). PA strategies included: PE teaching strategies to maximise

activity levels, individual student PA plans including long- and short-term personal goals, enhanced school sport programmes, modification of school policies, supervised recess activities, increased facilities and equipment available during recess, after-school PA programmes through linkages with community groups, and parental engagement through regular information sent home (Sutherland et al., 2013). At 12-month follow-up, students attending intervention schools participated in significantly more MVPA, four minutes more, compared to control students (Sutherland et al., 2016). This particular intervention is one of the few school-based PA interventions in the literature which specifically targets low SES areas. Other intervention examples within low SES areas have been single-component in nature, for example targeting the recess period with playground structures and markings (Ridgers et al., 2007), and also educational classes relating to self-monitoring and health benefits of PA or fundamental movement skills (Salmon, Ball, Hume, Booth, & Crawford, 2008). This highlights the overall need for multi-component school-based PA interventions which target low SES areas, as previous implementation is very limited.

The example multi-component school-based PA interventions explored highlight the potential which implementing multiple strategies has for positively impacting children's PA levels. Further research has also supported the use of multi-component interventions within schools, by showing multi-component interventions to have a positive impact on the PA levels of adolescents in particular (Murillo Pardo et al., 2013; Owen, Curry, Kerner, Newson, & Fairclough, 2017; van Sluijs, McMinn, & Griffin, 2007). Results from a 2015 meta-analysis indicated that as the number of CSPAP

components included in an intervention increased, the effect size associated with change in daily PA also increased (Russ, Webster, Beets, & Phillips, 2015).

It is only recently, particularly in the UK, that schools have been set a target for the amount of MVPA that should children should be achieving within school hours (30 minutes of MVPA per school day) (HM Government, 2016). Also, PA strategies will now be taken into consideration during school inspections (HM Government, 2016). Although PA intervention studies have been welcomed into schools with the prospect of student health being positively impacted, there is now more of an onus on schools themselves to demonstrate and implement strategies which will help their students to achieve the recommended PA guidelines. For interventions to have a sustained impact on outcomes, an intervention period of at least one year is said to be most effective (Lai et al., 2014). Follow-up (12-months or longer) results of previous PA interventions have not always demonstrated sustained positive effects on PA (Gorely et al., 2011; Harrington et al., 2018). Strategies implemented may be dependent upon the intervention and its resources, which when the intervention period comes to an end, the strategies within schools do so too. Now more than ever, schools need PA strategies which are creative in their ability to positively impact PA. Schools require strategies that can be integrated into the school day with limited impact on learning time, strategies that are low cost, and also strategies that are not reliant upon external resources that can be sustained once intervention trial periods are over.

2.10 School-Based Intervention Process Evaluation

Although the different multi-component interventions discussed in this chapter were all able to have a positive effect on PA levels, research has showed that multi-

component interventions may not always be successful at increasing PA in CYP (Okely et al., 2017; Van Kann et al., 2016). Multi-component interventions can be difficult to successfully implement. This was previously reported by the “Girls in Sport” randomised trial which found that schools did not implement the intervention as intended, with only four of the 12 participating schools doing so (Okely et al., 2017). Whether school-based multi-component interventions succeed at positively impacting PA levels or not, it is important to understand how they have been implemented in practice, so that they can be further developed for future practice. This assessment of implementation is said to be essential to understand whether the intervention is internally and externally valid (Durlak & DuPre, 2008). An accurate interpretation of either positive or negative outcomes is dependent on having an understanding of which aspects of an intervention was delivered and how (Durlak & DuPre, 2008).

The process evaluation of interventions is advocated by the UK MRC, which deems it to be an essential part of designing and testing complex interventions (Moore, Audrey, Barker, Bond, Bonell, & Hardeman, 2015). However, a review of the literature surrounding the implementation of school-based PA interventions conducted in 2015 concluded by stating that the literature base was lacking in both quantity and quality (Naylor et al., 2015). A lack of standardised definitions and measurements of implementation contributes to the scarce amount of implementation data reported in the literature (Naylor et al., 2015).

In the process evaluation research that has been conducted, positive links between the level of implementation and targeted health outcomes have been established

(Naylor et al., 2015). However, these outcomes vary, for example from enjoyment of PA to BMI, and not PA levels (Naylor et al., 2015). Process evaluation research is also useful for establishing factors that influence implementation. Factors that are consistent in the literature are important for researchers designing school-based PA interventions to consider (Naylor et al., 2015). Six commonly cited categories reported in the literature include: teacher characteristics (self-efficacy), intervention characteristics (compatibility, availability and quality of resources), school characteristics (supportive climate), and the support system (training) (Naylor et al., 2015). These categories of influence are similar to that of a systematic review which explored the barriers and facilitators to the implementation of PA policies in schools (Nathan et al., 2018). The most frequently reported barriers of this review were: environmental context and resources (availability of equipment, time or staff), 'goals' (school priorities), 'social influences' (support from school boards), and 'skills' (teacher ability to implement the policy) (Nathan et al., 2018). Evaluations of school-based interventions are increasingly seeking the perspectives of teachers to understand feasibility and acceptability. In the growing research area of classroom-based PA implementation, perspectives from teachers have provided useful and important considerations for future interventions (Dyrstad, Kvalø, Alstveit, & Skage, 2018; Routen, Johnston, Glazebrook, & Sherar, 2018). Example teacher reported factors which influence classroom PA implementation include, time, behavioural management, space, and teacher characteristics such as a lack of knowledge (Dyrstad et al., 2018; Martin & Murtagh, 2017c; Routen et al., 2018).

2.11 Participant Recruitment in School-Based Research

When seeking to evaluate school-based PA intervention and collect data from child participants, a key consideration for researchers is the recruitment and consent process. This can be difficult and time consuming, particularly if it is within a school setting in which an external researcher can face many hurdles to obtain parental consent, more so than many other research areas (Bergstrom et al., 2009). A person recruited to any study should provide their informed consent to take part and when such person is a child the situation is complicated by the need to obtain consent from their legal guardian/parent (Spence, White, Adamson, & Matthews, 2015).

For guardian/parental consent to be obtained, commonly the parent or guardian will receive a letter from the researchers outlining the study and procedures, with a requirement of signed written permission for their child to participate to be returned (Jason, Pokorny, & Katz, 2001). This active-consent process has been shown to result in participation rates between 30%-60% in school-based research on adolescent risk behaviours relating to health (Tigges, 2003). There are numerous opportunities for breakdowns to occur in the “school-to-home-to-school” consent form process (Blom-Hoffman et al., 2009). It has been cited that consent documents are not returned to researchers because parents do not receive the forms or forget to sign them (Jones et al., 2014). Other reasons include: inconvenience; parents assuming that their child is not interested; feeling that the study is not relevant or could potentially distract their child from academic pursuits (Jones et al., 2014).

Research has aimed to discover whether differences occur between students whose parents provide written consent and those who do not return consent forms for

research studies. The possibility that children of consenting parents may differ in important ways from children of non-consenting parents poses a threat to the validity of research findings (Anderman et al., 1995). A survey study of smoking behaviours found that boys, students with poor grades and students involved in health-risk behaviours such as smoking were the most likely to have parents or guardians who did not respond and give consent to participate (Unger et al., 2004). An Australian study found that active consent (parents being required to provide consent to take part) was associated with the under-estimation of childhood obesity prevalence, particularly in girls (Strugnell et al., 2018). Ethnic minority parents are also more likely to fail in returning consent forms as are those from socio-economically disadvantaged backgrounds and living in single-parent homes (Fletcher & Hunter, 2004). When active consent was used in a study by Spence et al. (2014), consent rate decreased as level of deprivation increased. Such sub-groups of the population that may be difficult to reach or involve in research or public health programmes are described as 'hard-to-reach' (Shaghaghi, Bhopal, & Sheikh, 2011). 'Hard-to-reach' populations may be characterised by a group of disadvantaged attributes such as illiteracy or being uncooperative (Shaghaghi et al., 2011). The consenting process can be even more challenging when parental English language skills are limited or literacy is low (Jones et al., 2014).

Informing parents about the research project prior to requests for active consent has been suggested as a useful and simple strategy to facilitate participation (Wolfenden, Kypri, Freund, & Hodder, 2009). Starting with an introduction letter to families has been previously utilised and can be distributed through school newsletters or other

parent communication channels (Cline, Schafer-Kalkhoff, Strickland, & Hamann, 2005). A positive relationship between school officials and researchers has also been advocated in order to motivate school staff to engage in efforts required to collect consent forms over time (Ji, Pokorny, & Jason, 2004). School support has been shown to be a significant factor when engaging in attempts to retrieve any remaining consent forms which are not received in the initial return rate (Ji et al., 2004). Efforts to secure early direct contact with the school principal and school staff not only to promote the research but also to secure their support should not be undermined by researchers, particularly as principals can have influence on parental decisions regarding their child's participation (Wolfenden et al., 2009). The power of important school staff can be implemented through the use of a signed cover letter (Stein et al., 2007). In addition to these efforts, distribution of consent forms attached with other school related documents or enrolment forms that parents are also required to sign and return has been shown to yield a higher rate of return (Ji et al., 2004; Stein et al., 2007). These type of school forms which are of importance may encourage parents to pay more attention to attached research consent forms (Stein et al., 2007).

Although these efforts can aid in reducing any breakdowns in the "school-to-home-to-school" consent form process, there is still a dependence and reliance on schools to retrieve forms on a daily basis following distribution, with little researcher control. An alternative method is for researchers or project staff to meet parents in person allowing for direct rather than mediated communication (Wolfenden et al., 2009). Research staff attendance at school open days or parent teacher meetings allows for effective promotion of study participation and provides an opportunity for parents to

question the researchers (Wolfenden et al., 2009). For example, to gain parental consent researchers have attended school-based functions at a location that parents are required to pass to complete school-related forms which subsequently provides the opportunity to get project forms completed and collected immediately (Ji et al., 2004). This method has shown to return a high rate of consent (Ji et al., 2004). However, this method is reliant upon good attendance from parents. Low consent rates are a possibility from school-based events if they are not well attended or project staff are situated where parents are not required to stop and therefore do not come into contact with or meet project staff (Ji et al., 2004).

Overall, the primary need for active consent procedures is for parents to have information about a research study which they can use to make an informed decision regarding whether or not they wish for their child to participate (Blom-Hoffman et al., 2009). An alternative is to pursue passive (opt-out) consent. The passive consent procedure provides a method for parents or guardians to retract permission to take part in a study, if this is not received within a pre-determined and shared timeframe, parental consent is assumed (Pokorny, Jason, Schoeny, Townsend, & Curie, 2001). It is argued that passive consent is necessary to obtain high participation rates (Pokorny et al., 2001). Ethical concerns have however been raised regarding the inclusion of children whose parents may actually oppose participation but they have not returned the form, or perhaps have never received or read the consent materials (Hollmann & McNamara, 1999), or have not understood the information received (Tigges, 2003). To enhance ethical applications for opt-out procedures, obtaining documented support from head teachers and governors for its use has previously been used

(Spence et al., 2015). Head teachers have argued that by using active consent children excluded are those whose parents routinely fail to return forms sent by schools (Spence et al., 2015).

When passive consent is used, parental permission is typically obtained for 93-100% of students (Tigges, 2003). PA related school-based studies have employed passive consent procedures. For example, the evaluation of a peer-led health promotion model through the use of behavioural questionnaires and accelerometers in which students were recruited through a passive 'opt out' letter sent home to parents (Audrey, Bell, Hughes, & Campbell, 2013). From 928 Year 8 pupils only 12 parents/carers returned the opt-out letter (Audrey et al., 2013). The 'Active for Life Year 5' study which involved 60 primary schools in the South-West of England also used passive consent to recruit 2,221 children (Kipping et al., 2014; Lawlor et al., 2011). Measurements in this study included: accelerometer assessed PA and ST, questionnaires, and BMI (Kipping et al., 2014). A reason put forward by this project in choosing opt-out consent was that it is consistent with the consent process currently used for the NCMP. This is administered in schools by Public Health England and the Department of Health and involves measurement of children's height and weight (Lawlor et al., 2011; Public Health England, 2017b). Furthermore, in a Danish study using accelerometers and global positional system devices to assess gender and age differences in children's PA, a passive informed consent procedure was also used (Klinker et al., 2014), with the rationale that this approach was ethically appropriate in such low risk research (Santelli et al., 2003).

2.12 Summary of literature

The literature review has highlighted the importance of PA participation to children's physical and mental health. Furthermore, as current PA levels of CYP worldwide and also more specifically in the UK are less than the recommendations, interventions to promote PA are warranted. Interventions may have increased significance for CYP from a low SES background due to the health inequalities which are evident in these populations. The literature suggests that the school environment is key for PA promotion in CYP, and that school-based interventions which are multi-component targeting numerous areas of the school day with different strategies, hold the most promise for positively effecting PA levels. Furthermore, strategies which have a limited impact on learning time available due to the crowded curriculum, and are also low in cost, are necessary for them to be sustainable in schools. The literature also highlighted that accelerometers are a valid method for evaluating PA levels in children and subsequently the effectiveness of interventions. Moreover, raw data in particular should be analysed. Finally, it is important that interventions are studied in terms of their implementation and fidelity, as this process evaluation research can improve understanding of how interventions have been implemented in practice, so that they can be further integrated into 'real world' school settings.

Chapter 3: General Methods

3.1 Introduction

Across the studies completed for this thesis there are many consistent methods used. The purpose of this chapter is to describe these methods. Any additional methods or study-specific procedures will be described in the relevant chapters.

3.2 Ethics

All studies received ethical approval from the Faculty of Arts and Sciences Research Ethics Committee at Edge Hill University (Study 1, ref #SPA-REC-2015-183; Study 2, 3 and 4, ref #SPA-REC-2016-342).

3.3 Research Assistants

The lead researcher carried out all measures, accompanied by research assistants who comprised of academic colleagues, undergraduate students, and West Lancashire Sport Partnership (WLSP) coaches. WLSP deliver PE, school sport, and PA programmes in schools across the region. Academic colleagues who assisted with data collection did not require any training due to the experience they already had in collecting the measures within their own research. Undergraduate students who assisted with data collection were required to attend a one-hour training workshop. During this workshop students were guided through each measure that they could be required to assist with or collect themselves when attending data collection sessions. The protocol of each measure (as described in the sections below) were provided on a written document for the students to study. They also received a questionnaire pack to read so as to understand the questions if a participating child asked for help. Given the busy teaching schedule of the WLSP coaches, they were unable to attend a training

workshop. Training for WLSP coaches was given at school sites before data collection began. As this training was less thorough than the training which undergraduate students received, whenever possible WLSP coaches were not left to collect a measure alone.

When data collection procedures took place the class teacher and/or teaching assistant were asked to remain present to oversee the activities. Anthropometric measurements were taken in a private area whereby both the children and researcher were both still visible to the class teacher but were not overlooked. Therefore, no research assistants were ever left alone when conducting data collection.

3.4 Participants

All head teachers (15) from Skelmersdale primary schools were invited to take part in the project and initially attend a talk which took place in June 2015. This talk outlined the plans of the project and the reasoning behind it. Following this meeting, 12 head teachers expressed an initial interest in taking part and subsequently met the lead researcher and the WLSP director for more detailed project talks. After these meetings took place in January 2016, seven schools committed to taking part in all four studies/phases of the project.

Within each study Year 5 children (ages 9-10 years) were the participants. The participating Year 5 children in each study are different sets of children due to each study taking place in separate school years. Some schools expressed an initial interest in tracking the children and having consistent participants across the three studies. However, Year 4 children (ages 8-9 years) were deemed too young to be able to

understand the questionnaire measures and Year 6 (ages 10-11 years) is a busy and important year in which data collection would be too difficult to conduct and fit in. This age group (9-10 years) has also been previously studied in school-based PA interventions and is an important age range to intervene with when considering the PA drop off over the primary to secondary school transition years (Lau, Dowda, McIver, & Pate, 2017). Figure 3.1 demonstrates the flow of the participants in each study. A more detailed flow of participants is outlined in Chapter 6 for the third study in which a randomised controlled trial (RCT) was conducted.

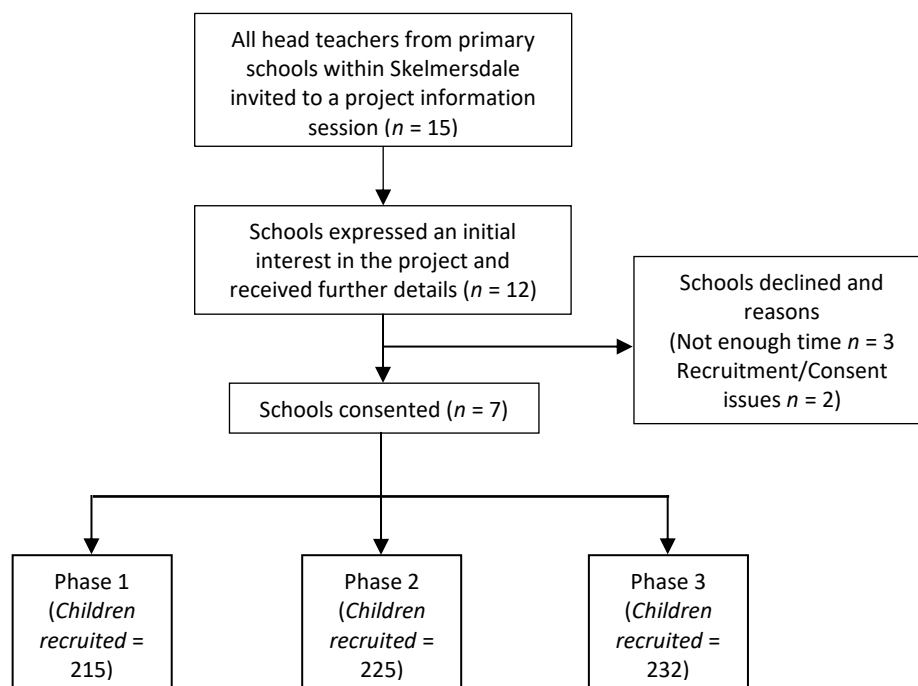


Figure 3.1. Flow of schools and participants throughout the programme of research.

3.5 Consent

For Study 1 parental consent packages were provided to schools to distribute to potential participating children (all Year 5 children). These information packages included a covering letter, project information sheet detailing a description of all the measures which children would participate in, a parental ‘active’ consent form, and a

child assent form. Parents/carers were required to sign and return the form for their child to take part. Numerous parents' evenings, parents' meetings, and assemblies were attended to speak to children and parents regarding the project. Whilst these recruitment strategies aided informed consent return rates, they also placed a large demand on time because of poor attendance from parents/carers at parent meetings, and parents/carers not having time to discuss the project with the team during parents' evenings. Further delays were caused waiting for scheduled parents' evenings to occur, and project meetings with parents/carers had to be organised well in advance to allow sufficient time for parents/carers to be notified. Resultantly, a four to five-month period was necessary to gain consent for Study 1 and the net effect was a significant delay in the collection of data.

It was anticipated that a passive consent procedure would greatly reduce the time needed to recruit participants for the second and third study of the thesis, for which parents/carers only signed and returned forms if they did not want their child to participate. Therefore, in project meetings with the participating schools a passive consent approach was discussed and the subsequent desires of each individual school was considered. Six out of the seven participating schools verbally supported the use of a passive consent approach, commenting on it being standard practice with their parents/carers (e.g., allowing promotional photography of pupils, participation in school sports teams). These schools therefore did not consider passive consent to be unusual or exceptional in other circumstances. Written support from those in favour of an 'opt out' approach was received from four senior staff members (out of six schools). These documents of support were used to strengthen the ethical application.

Ethical approval was granted to proceed with passive consent. The one school who wished to continue with the active consent procedure received similar documentation to that used in Study 1 and agreed to send reminders to parents/carers for consent forms to be returned. Parental packages were also similar for schools who chose to use passive consent, however an opt out consent form was used. All documentation was sent home a minimum of two weeks before data collection was due to start to ensure that parents/carers had sufficient time to respond and ask questions about the project. For schools that chose to use passive consent it was recognised that both school staff and researchers should ensure that parents/carers had received the information and therefore had the option to withdraw their child should they so wish to do so. Multiple communication methods were used such as reminders in school newsletters, verbal communication from class teachers at the start and end of the school day, as well as direct text messages via school systems. Regardless of consent approach, all parents/carers had the opportunity to contact the research team to discuss the study via email or telephone. Further, a link to an online folder to view documents, such as an example questionnaire and further information sheets with more detail about the measures and procedures were produced. In both active and passive consent procedures, children were required to complete an assent form before taking part in the data collection session.

3.6 Anthropometrics

Stature was assessed to the nearest 0.1 cm using a portable stadiometer (Leicester Height Measure, Seca, Birmingham, UK). Body mass was assessed to the nearest 0.1 kg (813 scales, Seca). Body mass index (BMI) was calculated as body weight in

kilograms divided by height in meters squared for each participant. BMI z-scores were assigned (Cole, Freeman, & Preece, 1995) and age and sex specific BMI cut points established children as normal weight or overweight/obese (those who were underweight were grouped into the normal weight category) (Cole, Bellizzi, Flegal, & Dietz, 2000). Waist circumference was measured at the midpoint between the bottom rib and the iliac crest to the nearest 0.1 cm using an anthropometric tape measure, and the percentage of waist circumference-to-height ratio (%WtHR) was calculated as a measure of central adiposity (Mehta, 2015). Gender-specific equations were used to predict children's age from peak height velocity (APHV), as a proxy measure of biological maturation (Moore et al., 2015). The equations for boys and girls are presented below.

Girls:

$$\text{Maturity Offset} = -7.709133 + [0.0042232 \times (\text{Age} \times \text{Height})]$$

Boys:

$$\text{Maturity Offset} = -7.999994 + [0.0036124 \times (\text{Age} \times \text{Height})]$$

3.7 Area-level deprivation

Area/neighbourhood-level deprivation was calculated using the 2015 Indices of Multiple Deprivation (IMD) (The English Indices of Deprivation 2015, 2015). The IMD is a UK Government produced deprivation measure for England comprising income, employment, health, education, housing, environment, and crime. IMD rank scores were generated from home post codes (parent-reported with active consent, child/school-reported with passive consent) using the National Statistics Postcode Directory database. Every small area in England is ranked from one (most deprived

area) to 32,844 (least deprived area). Deprivation 'deciles' are also published, matching IMD rank scores to a corresponding IMD decile, where decile one represents the most deprived 10% of areas nationally. The use of the IMD to determine deprivation has been used in many previous UK based studies (Fairclough et al., 2013; Noonan et al., 2016; Jago et al., 2017).

3.8 Psychological Outcomes

Children's perceptions of PA self-efficacy and enjoyment were assessed through a paper questionnaire pack. Self-efficacy and enjoyment were selected to be assessed as they are two predisposing variables of influence on children's PA within the YPAPM (Welk, 1999). Questions were completed by children in the classroom environment under the guidance of a class teacher, teaching assistant (most commonly, but not always present) and at least two research assistants. Teachers were asked to indicate any children with reading or comprehension issues who were then provided with one-to-one support. Eight items measuring self-efficacy (Motl et al., 2000) and 16 items measuring enjoyment (Motl et al., 2001) were included and measured on a 5-point scale ranging from 1 ("Strongly disagree") to 5 ("Strongly agree"). These questionnaires have previously demonstrated strong factorial validity (Motl et al., 2001; Motl et al., 2000).

3.9 Cardiorespiratory Fitness

The 20m multistage shuttle run test was conducted to provide an estimate of cardiorespiratory fitness (CRF) (Léger, Mercier, Gadoury, & Lambert, 1988). Children were required to keep in time with an audible 'bleep' which progressively became

quicker as the intensity of the test increased. Children were encouraged to run for as long as possible, pushing themselves to exhaustion but were also made aware that they could drop out from the test whenever they wished to do so. This well-established test has been previously used with children of a similar age to those in the current study (Boddy, Fairclough, Atkinson, & Stratton, 2012; Fairclough et al., 2013), and is also deemed valid and reliable for use with children (Liu, Plowman, & Looney, 1992; van Mechelen, Hlobil, & Kemper, 1986). The total number of shuttles completed by each participant was recorded as a proxy measure of CRF.

3.10 Device-Based Physical Activity Measures

Devices used were the ActiGraph GT9X triaxial accelerometer (AG, Pensacola, FL, USA) and the GENEActiv (GA; Activinsights, Cambs, UK). Each time the monitors were distributed, children were instructed to wear the devices on their non-dominant wrist for seven consecutive days. Children were instructed to wear the accelerometers all the time ($24 \text{ h} \cdot \text{day}^{-1}$) except when engaging in water-based activities such as bathing and swimming. A 24-hour protocol has previously produced increased wear time compliance in children and provides opportunity to study sleep (Tudor-Locke et al., 2015). Log sheets were used each time the monitors were distributed. This allowed children to record times when the accelerometer was removed and replaced and also served as reminders to the children. Within Study 1, through the 'active' consent procedure parents provided their mobile telephone number and consented to being sent text reminders for the children to wear and then return the monitor. As it was not possible to get telephone numbers in Study 2 and Study 3 due to the 'passive'

consent procedures, schools were asked to send reminders to parents via their own school text systems.

After seven days of wear, data were downloaded to a format which facilitated raw data processing (AG; ActiLife v6.11.9 saved as GT3X files and converted to CSV format; GA; GA v2.2 software saved as binary files). Raw data files were processed in R (<http://cran.r-project.org>) using GGIR which is an open source package that facilitates the processing of raw accelerometer signals (version 1.5-16). GGIR converted the raw triaxial accelerometer signals into one omnidirectional measure of acceleration termed the Euclidean norm minus one (ENMO; vector magnitude taken from the three axes minus the value of gravity with negative values rounded up to zero) (van Hees et al., 2014; van Hees et al., 2013).

ENMO values were averaged per 1 s epoch over each of the seven monitored days (Fairclough et al., 2016). Accelerometer non-wear was determined using the method of van Hees et al. (2013), which has been applied previously in studies involving children (Fairclough et al., 2016; Noonan, Boddy, Kim, Knowles, & Fairclough, 2017; Rowlands et al., 2016). Non-wear time was estimated from the standard deviation and value range of each accelerometer axis, calculated for moving windows of 60-min with 15-min increments (van Hees et al., 2013). If two out the three axes had a standard deviation less than 13.0 mg or if the value range was less than 50 mg, the time window would be classified as non-wear time (van Hees et al. 2013).

Thesis Study Map

Study	Objectives and Key Findings
Study 1: Predictors of Segmented School Day Physical Activity and Sedentary Time in Children from a Northwest England Low-Income Community	Objectives <ul style="list-style-type: none">• Establish the current MVPA and ST levels of children aged 9-10 years who attend schools in a low-income town of Northwest England.• Investigate the child and school-level influences on children's PA and ST during segmented school hours.
Study 2: Acceptability and feasibility of single-component primary school physical activity and sedentary behaviour interventions to inform the AS:Sk Project	
Study 3: Evaluation of a Pilot School-Based Physical Activity Clustered Randomised Controlled Trial — Active Schools: Skelmersdale	
Study 4: The process evaluation of Active Schools: Skelmersdale: a pilot school-based physical activity clustered randomised controlled trial	

**Chapter 4 (Study 1): Predictors of Segmented
School Day Physical Activity and Sedentary Time
in Children from a North-West England Low-
Income Community**

This study has been published in the International Journal of Environmental Research and Public Health and can be found in Appendix 4.

Taylor, S. L., Curry, W. B., Knowles, Z. R., Noonan, R. J., McGrane, B., & Fairclough, S. J. (2017). Predictors of Segmented School Day Physical Activity and Sedentary Time in Children from a Northwest England Low-Income Community. *Int J Environ Res Public Health*, 14(5). doi: 10.3390/ijerph14050534

4.1 Author Contribution

S.T. carried out preparations for data collection, including the set-up of accelerometers and subsequently collected the data. Assistance for data collection was received from WLSP coaches and undergraduate students from Edge Hill University. S.T. inputted all the data, downloaded the raw PA data, and conducted the full analyses of the data. Training on statistical analysis was received from S.F. S.T. wrote the manuscript. W.C., B.M., Z.K., R.N., and S.F. provided comments on the manuscript and read and approved the final version of the manuscript.

4.2 Introduction

To develop effective PA interventions within schools it is important to understand all factors which influence participation (Sallis, Prochaska, & Taylor, 2000). PA and SB are complex and their occurrence varies within different domains. Youth PA and ST correlates are represented at the individual, inter-personal, organisational, and system levels (Bauman et al., 2012). Lower SES home environments typically provide more opportunities for ST and fewer for PA (Tandon et al., 2012). It has been argued that more positive attitudes towards the value of PA and healthy lifestyles are evident

in families with a higher SES, which may be reflected by high SES children attaching greater importance to PA participation for health benefits, relative to perceptions from a comparable group of low SES children (Seabra et al., 2013). However, use of different methods of measuring PA and SES suggest that associations reported between SES and children's PA are equivocal (Stalsberg & Pedersen, 2010). In addition to SES, correlates consistently associated with PA in children include sex, age, ethnicity, perceived competence, and perceived barriers (Sterdt et al., 2013). Whilst it is useful to understand what influences children's habitual PA and ST, these may not be consistent within specific contexts and environments such as schools (Stanley, Ridley, & Dollman, 2012) and thus their investigation is warranted.

Schools are identified as important settings for health promotion through PA. In the UK, the Government's plan for action to reduce childhood obesity has reinforced the importance of school recommending that children should accumulate at least 30 minutes of MVPA within school every day (HM Government, 2016). For schools to be active environments and for successful interventions to be implemented, it is important to understand what influences PA-related behaviour during school hours. The aim of this study, therefore, was to investigate the child-level and school-level influences on children's PA levels and ST during school hours in a sample of English children who live and go to school in a high deprivation community. Child-level influences are highlighted as significant to influencing PA participation within the socio-ecological framework as intrapersonal factors (McLeroy et al., 1988) and also within the YPAPM as personal demographics (Welk, 1999). Additionally, the socio-ecological model directs attention towards the characteristics of locations including

environmental factors which either facilitate or hinder participation, thus indicating that school-level influences are also of importance (Sallis et al., 2006).

4.3 Study-specific methods

4.3.1 Participants

Participating schools received the relevant paperwork to invite all Year 5 children ($n = 243$) to participate in the study. Returned signed parent/carers consent and child assent forms were received from a sample of 215 children aged 9–10 years (88% participation rate).

4.3.2 Child-Level Measures

4.3.2.1 Device-Based Physical Activity Measures

Children wore an ActiGraph GT9X triaxial accelerometer (ActiGraph, Pensacola, FL, USA) which were each initialised to record raw accelerations at a frequency of 30 Hz. Research has stipulated that activity classification accuracy was not compromised when a sampling rate of 80 Hz decreased to 10 Hz (Zhang et al., 2012). The use of a lower sampling frequency (in comparison to 100 Hz for example) helped to reduce data load and decreased the amount of time spent processing the data, which was particularly important when other accelerometer-based studies were on-going in the university at the same time. Data collection took place during the regular school term from May to July 2016, therefore data were representative of usual spring/summer free-living activities. Accelerometer wear time inclusion criteria were set to 16 hours for a minimum of three weekdays. Although this minimum hour criteria has been previously used (Sabia et al., 2014), it exceeds what has been recommended to produce reliable estimates of PA (Rich et al., 2013). This higher inclusion criteria was

selected due to the segmented nature of the PA data and has been previously used to analyse sleep (van Hees et al., 2015). The time periods explored in the analyses included whole weekday, school day, morning break, lunch break, and PE. These time segments were defined by the class teacher in each school.

Published ENMO prediction equations were used to identify cut-points for classifying activity into ST, LPA, and MVPA (Hildebrand et al., 2014). The Hildebrand equations were solved for 2 METs (ST/LPA) and 4 METs (MVPA) resulting in the ENMO cut-points displayed in Table 4.1.

Table 4.1 ENMO cut-points used.

	Sedentary Time	Light PA	Moderate PA	Vigorous PA
ActiGraph (mg)	0-32	33-369	370-706	707-8000

4.3.2.2 Sleep

Sleep was estimated within the GGIR R package (version 1.5-16; <http://cran.r-project.org>). As wrist-worn accelerometer data was used it allowed for the estimation of the arm angle relative to the horizontal plane to characterise sleep (van Hees et al., 2015). Using a five minute criteria, nocturnal bouts of sustained inactivity and therefore sleep were defined as no change in arm angle greater than 5 degrees (van Hees et al., 2015).

4.3.2.3 Other

The child-level measures listed below were also collected using the procedures outlined in Chapter 3.

- *Anthropometrics.*
- *BMI z-score.*
- *CRF.*
- *Psychological Outcomes.*
- *Area-level deprivation.*

4.3.3 School-Level Measures

4.3.3.1 School PA Provision Survey

A UK-culturally appropriate survey to indicate the PA environment, practices, and provision of the participating schools was created through the use and adaptation of three existing US-based PA audit tools. These included, the School Physical Activity Policy Assessment which has three distinct modules, PE (47 items), recess (27 items), before, during and after school (15 items) and test-retest results suggested reliability (Lounsbery, McKenzie, Morrow, Holt, & Budnar, 2013); the School Health Index which is defined as a community organising and education tool and not a research tool, with eight different modules two of which were specific to PA (Brener et al., 2006) ; and the Active Schools Self-Assessment Tool which is designed to see where schools already “shine” and where needs stepping up in terms of PA. Questions are separated into sections relating to PE, PA before and after school, PA during school (including

recess and classrooms), staff involvement, and family/community involvement (<https://www.activeschoolsus.org>).

This resulted in a 20-item survey which was completed by head teachers or the most appropriate alternate member of staff from each school (see Appendix 3). The survey was available to complete online or in paper format. Questions in the 20-item survey covered various parts of the school day relating to PA, including the amount of provision before and after school as well as aspects relating to recess and PE lessons. A 4-point scale was used to answer questions (0–3), with a score of three representing optimal PA environment/practice/provision and zero representing poor or non-existent PA environment/practice/provision. The item scores were summed, divided by 60, and converted to percentage scores.

4.3.3.2 Playground Space

Aerial views of the schools' playground areas were located using the Google™ Earth Pro application (version 7.1). Playground areas were calculated using the polygon tool and summed for each school to provide an estimate of playground spatial area (Fairclough, Beighle, Erwin, & Ridgers, 2012; Fairclough, Ridgers, & Welk, 2012). MPA and VPA has previously been shown to be associated with playground space in children (Fairclough, Beighle, Erwin, & Ridgers, 2012; Fairclough, Ridgers, & Welk, 2012). The number of enrolled children in each school (number on roll) was obtained from school records.

4.4 Analyses

Individual and school level descriptive statistics (mean and standard deviations) were calculated for all measured variables. Independent t-tests assessed sex differences in the main outcomes of ST, LPA, and MVPA. To account for the clustering of children within the seven schools, multilevel modelling was performed for the main analysis using MLwiN Version 2.36 (Rabesh, Charlton, Browne, Healy, & Cameron, 2009). This method of analysis has been described as an extension of 'standard' regression techniques (Twisk, 2006). A 2-level data structure defining children as the first level unit of analysis and schools as the second level unit was used (Twisk, 2006). Separate multilevel prediction models with random intercepts were constructed to identify significant predictors of ST, LPA, and MVPA during the school day (range 8.45 am–3.15 pm), morning break (mean 15.7 min), lunch break (time on the playground only, mean 37.9 min) and total PE time (mean 90.7 min; 12 models in total). Morning break and lunch break periods were daily occurrences for all participating schools. PE frequency differed between schools and was either once or twice per school week. A forward selection procedure was used for the prediction models (Twisk, 2006). School- and child-level predictors were entered into the models and were retained when they were significantly associated with the outcomes and remained significant when subsequent predictors were added to the models. Therefore, non-significant predictors which were not in the final models were not presented in the results. Regression coefficients in the models were assessed for significance using the Wald statistic and the alpha level was set at $p < 0.05$ (Twisk, 2006).

4.5 Results

4.5.1 Exploratory Analyses

The descriptive characteristics of the 215 children are displayed in Table 4.1. Around one-quarter of the children were classified as overweight or obese. The deprivation deciles of home postcodes ranged from 1–9, with 85% of children living within deciles 1–3. After children without sufficient wear time were excluded from the data set, there was an analytical sample of 186 children (87% compliance), whose descriptive characteristics did not differ from those of the excluded children. Characteristic difference between included and excluded children were analysed using a t-test. Table 4.2 presents the mean number of minutes spent in different PA intensities during weekdays, indicating that boys and girls did not achieve the recommended 60 minutes of MVPA on average. The mean number of minutes spent in the different PA intensities across the studied segments (school day/morning break/lunch break/PE) are also presented in Table 4.3.

Table 4.2. Descriptive characteristics of participating children (where applicable; Mean (SD)).

Measure	Boys (<i>n</i> = 110)	Girls (<i>n</i> = 105)
Age (y)	10.2 (0.3)	10.2 (0.3)
Stature (cm)	140.4 (5.9)	141.3 (6.8)
Body Mass (kg)	36.4 (8.4)	38.3 (10.6)
BMI (kg·m ²)	18.9 (4.0)	18.3 (3.2)
BMI z-score	0.5 (1.3)	0.5 (1.3)
Weight Status		
Normal Weight (%)	76.2	72.5
Overweight/Obese (%)	23.8	27.5
Waist Circumference (cm)	64.3 (10.0)	64.9 (10.3)
Maturity Offset (y)	-2.8 (0.3)	-1.6 (0.4)
IMD Rank	5746.5 (5831.6)	6077.6 (6922.1)
IMD Decile	2.3 (1.7)	2.4 (2.1)
CRF (Number of shuttles)	30.4 (16.5)	25.4 (11.7)

Table 4.3. Boys' and girls' sedentary time and physical activity (Mean and SD).

	Boys (<i>n</i> = 92)			Girls (<i>n</i> = 94)		
	ST	LPA	MVPA	ST	LPA	MVPA
Weekday	552.6 (125.4)	357.0 (65.8)	42.7 (20.0)	554.0 (107.0)	367.0 (57.8)	29.8 (13.4)
School day	198.4 (31.3)†	157.5 (27.4)	20.9 (8.7)‡	210.4 (32.6)†	151.9 (27.9)	14.3 (7.2)‡
Morning break	6.4 (3.0)	7.2 (2.0)	1.5 (1.1)‡	6.5 (3.1)	7.0 (2.0)	0.8 (.06)‡
Lunch break	17.0 (6.2)†	7.0 (2.2)†	6.0 (4.4)‡	19.8 (8.0)†	6.0 (2.0)†	3.1 (2.2)‡
PE	17.1 (8.1)	34.0 (5.7)	7.3 (4.1)†	18.6 (8.5)	33.5 (6.6)	5.9 (3.6)†

† Significant difference between sexes, $P < .05$. ‡ Significant difference between sexes, $P < .001$

4.5.2 Main analyses

School-level predictors entered into the multilevel models were number of enrolled students, playground area, and PA provision score (Table 4.4). Only six out of seven schools were included for the PA provision scores due to non-completion of the survey by one school. The multilevel analyses are reported in Tables 4.5-4.8.

Table 4.4. Descriptive school level predictors.

Variable	Mean (SD)	Range
No. enrolled students	277.6 (150.5)	102-579
Playground area (m ²)	2071.6 (815.5)	904-3121
PA provision score (%)	62.3 (9.5)	52-75

4.5.2.1 School day predictors

The only correlate to significantly predict school day ST was school day MVPA levels ($p < .001$), whereby one minute of MVPA during the school day predicted 1.9 minutes less ST during the same period ($p < .001$). Participation in school day ST predicted less participation in LPA (0.9 minutes, $p < .001$) and MVPA (0.1 minutes, $p < .001$) during the school day. CRF ($p < .001$) and number on roll ($p = .01$) were also inverse predictors of school day LPA. Conversely, CRF was a positive predictor of school day MVPA ($p < .001$), while maturity offset was an inverse predictor of school day MVPA ($p < .001$). Out of school MVPA was a significant inverse predictor of LPA in the school day ($p < .001$) and a significant positive predictor of MVPA in the school day ($p < .001$).

4.5.2.2 Morning break predictors

MVPA during the school day predicted less ST participation during morning break ($p < .001$). ST during the school day also predicted less morning break LPA ($p < .001$) and

MVPA ($p < .001$) but by only 0.1 minutes. Out of school MVPA predicted less participation in LPA during morning break ($p = .02$). Number on roll positively predicted ST ($p = .01$) and LPA ($p < .001$) at morning break. Those who were overweight or obese participated in significantly less MVPA during morning break ($p = .01$), and maturity offset was also an inverse predictor of MVPA ($p < .001$).

4.5.2.3 Lunch break predictors

MVPA during the school day predicted less ST participation during lunch break ($p < .001$). ST during the school day also predicted less lunch break LPA ($p < .001$) and MVPA ($p < .001$). Out of school MVPA predicted more MVPA participation during lunch break ($p = .002$). Number on roll was a positive predictor of both ST ($p = .045$) and MVPA ($p < .001$) during lunch break. WtHR predicted less MVPA during lunch break by 9 minutes ($p < .001$).

4.5.2.4 PE lesson predictors

Inverse relationships were evident between school day MVPA and ST during PE ($p < .001$), as well as school day ST and LPA ($p < .001$) and MVPA ($p < .001$) during PE. Overweight or obese children engaged in significantly more LPA during PE than normal weight children (2.6 minutes, $p = .001$). Further positive predictors of PE MVPA were PA enjoyment ($p < .001$) and out of school MVPA ($p < .001$), while maturity offset was an inverse predictor of MVPA during PE lessons ($p < .001$).

Table 4.5. Multilevel associations between child and school level predictors and school day ST and PA.

Correlate	School day ST		School day LPA		School day MVPA	
	β (SE) ¹	95% CI	β (SE)	95% CI	β (SE)	95% CI
Constant	235.65 (5.92)‡	224.05 to 247.25	354.0 (7.12)‡	340.04 to 368.0	24.01 (5.0)‡	14.21 to 33.81
Child level variables						
Maturity Offset (y)	NE ²		NE		-3.26 (0.60)‡	-4.44 to -2.08
CRF (total shuttles)	NE		-0.07 (0.03)†	-0.13 to -0.01	0.06 (0.03)‡	0.00 to 0.12
School day ST	NE		-0.87 (0.02)‡	-0.91 to -0.83	-0.11 (0.02)‡	-0.15 to -0.07
School day MVPA	-1.92 (0.21)‡	-2.33 to -1.51	NE		NE	
Out of school MVPA	NE		-0.32 (0.07)‡	-0.46 to -0.18	0.25 (0.06)‡	0.13 to 0.37
School level variables						
No. on roll	NE		-0.04 (0.02)†	-0.08 to -0.00	NE	
Playground area (m ²)	NE		NE		0.002 (0.00)†	0.00 to 0.00
School level variance	138.12 (84.44)		47.34 (26.22)		6.12 (3.91)	
Child level variance	419.16 (44.31)		30.60 (3.26)		25.29 (2.73)	
ICC	0.25		0.61		0.19	

¹ Beta values reflect differences in minutes of ST/LPA/MVPA for every 1 measured unit of each predictor variable. ² NE = not entered in final model. ICC, intraclass correlation coefficient. †P<.05, ††P<.01, ‡P<.00

Table 4.6. Multilevel associations between child and school level predictors and morning break ST and PA.

Correlate	Morning break ST		Morning break LPA		Morning break MVPA	
	β (SE) ¹	95% CI	β (SE)	95% CI	β (SE)	95% CI
Constant	3.83 (1.13)‡	1.62 to 6.04	12.52 (1.07)‡	10.42 to 14.62	2.33 (0.49)‡	1.37 to 3.29
Child level variables						
Maturity Offset (y)	NE ²		NE		-0.36 (0.11)‡	-0.58 to -0.14
Weight Status ³	NE		NE		-0.28 (0.12)†	-0.52 to -0.05
School day ST	NE		-0.04 (0.00)‡	-0.04 to -0.03	-0.01 (0.00)‡	-0.01 to -0.00
School day MVPA	-0.07 (0.01)‡	-0.09 to -0.05	NE		NE	
Out of school MVPA	NE		-0.03 (0.01)‡	-0.05 to -0.01	NE	
School level variables						
No. on roll	0.01 (0.00)††	0.00 to 0.02	0.007 (0.00)‡	0.00 to 0.01	NE	
School level variance	1.77 (0.98)		0.65 (0.39)		0.0 (0.04)	
Child level variance	1.52 (0.16)		1.42 (0.15)		0.43 (0.05)	
ICC	0.54		0.31		0.00	

¹ Beta values reflect differences in minutes of ST/LPA/MVPA for every 1 measured unit of each predictor variable. ² NE = not entered in final model. ³ Reference group for weight status was normal weight. ICC, intraclass correlation coefficient. †P<.05, ††P<.01, ‡P<.001.

Table 4.7. Multilevel associations between child and school level predictors and lunch break ST and PA.

Correlate	Lunch break ST		Lunch break LPA		Lunch break MVPA	
	β (SE) ¹	95% CI	β (SE)	95% CI	β (SE)	95% CI
Constant	10.70 (4.95) ††	1.0 to 20.4	17.77 (1.12) ‡	15.57 to 19.97	8.98 (2.43) ‡	4.13 to 13.74
Child level variables						
WtHR	NE ²		NE		-9.28 (2.96) ‡	-15.08 to -3.48
School day ST	NE		-0.06 (0.01) ‡	-0.08 to -0.04	-0.03 (0.00) ‡	-0.05 to -0.02
School day MVPA	-0.33 (0.04) ‡	-0.09 to -0.05	NE		NE	
Out of school MVPA	NE		NE		0.09 (0.03) ††	0.03 to 0.15
School level variables						
No. on roll	0.04 (0.02) †	0.00 to 0.02	NE		0.02 (0.00) ‡	0.001 to 0.03
School level variance	33.45 (18.16)		2.72 (1.52)		1.50 (0.96)	
Child level variance	11.4 (1.2)		2.25 (0.24)		6.24 (0.66)	
ICC	0.75		0.55		0.19	

¹ Beta values reflect differences in minutes of ST/LPA/MVPA for every 1 measured unit of each predictor variable. ² NE = not entered in final model. ³ Reference group for weight status was normal weight. ICC, intraclass correlation coefficient. †P<.05, ††P<.01, ‡P<.001.

Table 4.8. Multilevel associations between child and school level predictors and PE ST and PA.

Correlate	PE ST		PE LPA		PE MVPA	
	β (SE) ¹	95% CI	β (SE)	95% CI	β (SE)	95% CI
Constant	21.58 (2.48)‡	16.72 to 26.44	54.84 (3.74)‡	47.51 to 62.17	2.80 (2.63)	-2.35 to 7.95
Child level variables						
Maturity Offset (y)	NE ²		NE		-0.99 (0.29)‡	-1.56 to -0.42
Weight Status ³	NE		2.15 (0.83)††	0.52 to 3.78	NE	
PA Enjoyment	NE		NE		1.22 (0.34)‡	0.55 to 1.89
School day ST	NE		-0.10 (0.01)‡	-0.12 to -0.08	-0.02 (0.00)††	-0.04 to -0.01
School day MVPA	-0.29 (0.06)‡	-0.41 to -0.17	NE		NE	
Out of school MVPA	NE		-0.12 (0.05)†	-0.22 to -0.02	0.13 (0.03)‡	0.07 to 0.19
School level variables						
School level variance	33.55 (18.90)		26.91 (14.87)		6.55 (3.66)	
Child level variance	35.67 (3.78)		20.31 (2.15)		5.86 (0.63)	
ICC	0.48		0.57		0.53	

¹ Beta values reflect differences in minutes of ST/LPA/MVPA for every 1 measured unit of each predictor variable. ² NE = not entered in final model. ³ Reference group for weight status was normal weight. ICC, intraclass correlation coefficient. †P<.05, ††P<.01, ‡P<.001.

4.6 Discussion

This study investigated predictors of school environment PA levels and ST of children who predominantly (85%) live in the most deprived areas nationally. Significant child-level predictors were maturity offset, CRF, weight status, WtHR, ST, and MVPA, while the significant school-level predictors were number of children on roll and playground area.

Previous research has reported variables such as sex, SES, and self-efficacy to be predictors of children's habitual PA (Sterdt et al., 2013). However, these predictors were not associated with PA or ST during the whole school day or specific segments of the school day in this study. The fact that area-level deprivation was not a significant predictor was likely due to the homogeneity in the children's IMD scores. The exploration of children's time-specific PA has identified age and gender to be consistently associated with school morning break PA (Stanley et al., 2012). Significant differences were observed between boys and girls for school day ST and MVPA, for MVPA during morning break and PE, and for lunch break ST, LPA, and MVPA in the current study, but sex was not significantly related to ST or PA in the multilevel analyses. Previous research has shown the effect of sex on PA to reduce or even disappear when maturity status is controlled for (Bacil, Mazzardo Junior, Rech, Legnani, & de Campos, 2015; Fairclough & Ridgers, 2010). This research may explain why sex did not predict ST and PA, but maturity offset significantly predicted MVPA during the school day, morning break, and PE. Disengagement from PA aligning with maturation is associated with a variety of behavioural, social and biological factors (Sherar, Cumming, Eisenmann, Baxter-Jones, & Malina, 2010). Furthermore, the

contribution of biological maturity to variation in PA should consider factors such as activity context (Sherar et al., 2010). Results of this study indicate that children's maturity status influences MVPA in the school environment, thus it is important to understand how school PA practices and policies recognise this influence to enable all children to engage in MVPA during school hours regardless of their maturity status. Furthermore, the children in this study were largely pre- and early-pubescent. The influence of maturation may be exacerbated in high school environments as PA is known to gradually decline as adolescents progress toward the mature state, i.e., adulthood (Cumming, Sherar, Esliger, Riddoch, & Malina, 2014).

Sedentary time and MVPA were the most consistent predictors across the different periods, with MVPA significantly predicting less ST, and ST levels significantly predicting less MVPA. This is consistent with previous research studying break time periods of the school day, in which an inverse association was reported between sedentary activities and percentage of time engaged in MVPA (Roberts, Fairclough, Ridgers, & Porteous, 2012). Whilst our analysis found that one behaviour predicted less of another, this does not imply that ST displaces PA and vice versa. Marshall and colleagues (Marshall, Biddle, Sallis, McKenzie, & Conway, 2002) found correlations between sedentary behaviours and PA to be small and positive, suggesting ST does compete with and coexist with PA. However, small increases in MVPA levels within the school environment which help to reduce ST should be advocated due to the known health and development benefits of MVPA and negative health implications of excessive ST in children (Carson, Hunter, Kuzik, Gray, et al., 2016). The replacement of SB with PA is also particularly important for children who are overweight or obese. Weight status was a significant predictor in the current study, with those who were

overweight or obese participating in less MVPA during morning break for example. Results from intervention studies suggest that preventing excessive sedentary behaviour may be an effective approach in improving healthy weight among children (van Grieken, Ezendam, Paulis, van der Wouden, & Raat, 2012). As overweight and obese children have a higher chance of becoming overweight or obese as adults and subsequently being at risk for chronic diseases (Centers for Disease Control and Prevention, 2013), advocating reduced ST and increased MVPA in the school setting among this group is important. Additionally, out of school MVPA was a significant inverse predictor of LPA during the school day, morning break and PE, and a significant positive predictor of MVPA during the school day, lunch break and PE. Given that activity during the school day was low overall, it appears that children who accrued more MVPA out of school participated in more during school, regardless of individual schools' PA provision. Conversely, creating more opportunities for activity during the school day can prompt higher activity levels to be sustained out of school, which lends further support for promoting MVPA participation in the school setting (Dale, Corbin, & Dale, 2000).

A significant predictor of MVPA during PE lessons was PA enjoyment. This reinforces the need for children's PA experiences to be fun and enjoyable as PA enjoyment is a recognised mediator of behavioural change in PA interventions (Salmon, Brown, & Hume, 2009). This finding aligns with theories of motivation, in that participation in activities for joy or pleasure results in a greater adherence due to participants being intrinsically motivated to engage (Lubans et al., 2017). Enjoyment is a key principle of the recently proposed 'SAAFE' framework for the design and delivery of organised PA sessions for children and adolescents (Lubans et al., 2017). Our findings support this

principle in relation to MVPA participation during PE lessons. This is of significance due to the importance of PE within the school environment; research has shown that PE plays a considerable role in providing PA for children with increased activity levels on days in which PE is provided (Meyer et al., 2013). Furthermore, PE can develop fitness, gross motor skills and overall health (Committee on Physical Activity and Physical Education in the School Environment et al., 2013).

PA provision scores obtained by schools also significantly predicted PE MVPA levels. In the context of UK schools there is a need for an objective measure which captures how schools operate in relation to PA provision, as opposed to the US based tools previously published (Brenner et al., 2006; Lounsbery et al., 2013). Within UK schools government funding is provided to improve the quality and breadth of PE and sports provision in primary schools worth £150 million per year (Department for Education, 2015). Whilst not exclusively for PE delivery, UK schools have the freedom to determine how best to use this funding to improve curricular and non-curricular PA provision, but are expected to be accountable for measuring the impact of their spending (Department for Education, 2015). Elsewhere, such as in the US, school-based PA opportunities differ from state to state, district to district and from school to school based on decisions made by state policy makers (Lee, Burgeson, Fulton, & Spain, 2007). Local policies and the degree to which they are adhered to or enforced there impacts children's PA accrual in schools (Lounsbery et al., 2013). Given the differences between school operations in these examples of the UK and US, objective tools to measure school-based PA provision which are country-specific would be useful to help schools decide on how to use funding or to help policy makers understand what is being done at the level of individual schools. Furthermore, the use

of an objective tool would be useful for researchers who wish to implement school-based interventions targeting areas of the school day most in need of intervention. In our analyses, school-level variables had limited associations with ST, LPA, or MVPA. Furthermore, PA provision scores from the audit tool did not explain or capture the differences between schools. Variance of activity levels explained by differences between schools were substantial, suggesting behaviours during periods of the school day varied between the participating schools. For example, 54% of morning break and 75% of lunch break ST variance was explained by differences between schools. In comparison, a study examining children's ST and MVPA during recess found total variance explained by differences between schools to be 12% for ST (Ridgers, Fairclough, & Stratton, 2010). It is unclear why the between-school variance is higher than was reported by Ridgers et al. (2010), particularly for ST. There are however a range of different factors related to school break times which can vary between individual schools. The current analyses included PA provision, playground space, and number of children, while other studies have shown provision of equipment, climate, and number of permanent play facilities to be associated with PA behaviour (Ridgers, Fairclough, et al., 2010; Taylor et al., 2011). Thus, differences such as these which are particular to individual schools impact children's ST and PA, and serve to highlight the need for analyses to account for the contribution of schools to PA outcome variance.

Number of children on roll inconsistently predicted ST and PA, depending on the period. For example, at morning break number on roll predicted more ST and LPA, whilst at lunch break it was associated with more ST and MVPA. A review of the overall PA behaviour of 10-18 year olds found the presence of peers and friends to be associated with PA (Fitzgerald, Fitzgerald, & Aherne, 2012). This is to be expected in

contexts such as morning break and lunch break, particularly in younger age groups, as peers will always be present. A systematic review of PA during school recess found 48 studies that reported a negative association between number on roll and PA and 38 studies reporting no association (Ridgers, Salmon, Parrish, Stanley, & Okely, 2012). Given the inconsistencies of the current study and that of previous research, methodologies such as context-specific systematic observations and tools (e.g., SOCARP) (Ridgers, Stratton, & McKenzie, 2010) would help to further our understanding of children's PA-related social dynamics and behaviours.

4.6.1 Strengths and Limitations

It is acknowledged that cause and effect cannot be claimed from the current cross-sectional analyses. The subjective nature of the audit tool used and its completion by school staff is a limitation of the current study. Another limitation of the audit tool was that it was not validated for use. A further limitation was the use of timetabled school times to define the segments of break and lunch times and PE. Actual recording of specific school period times during monitor wear by teachers would allow greater certainty that the activity recorded took place in the period of interest. This though would place additional burden on class teachers to record these times on multiple occasions each day. Inter-rater reliability was not examined for measures. This is a weakness of the study as it could have implications on the data, particularly waist circumference. Research has highlighted that measuring waist circumference is subject to significant inter-operator variability and could potentially lead to misclassifying participants (Panoulas, 2008). A greater range of school-level predictors may have better explained differences between schools, for example the presence of equipment during break and lunch breaks, fixed equipment and playground markings.

The most important limitation is the cross-sectional nature of the research design which prevents conclusions being made regarding causality. A strength of this study was the use of objectively assessed PA. Furthermore, the use of raw accelerations avoids the uncertainty of pre-processed data such as counts and the possibility that signal filtering methods alter study results (Freedson et al., 2012; Peach et al., 2014). The use of raw data also gives an increased control over data processing as well as the opportunity to improve comparability and consistency between studies which use different monitors for example (Hildebrand et al., 2014). In addition, the multilevel analyses allowed for the nested nature of children within schools and also school level correlates to be studied.

4.7 Conclusions

The most consistent child-level predictors of behaviour were levels of MVPA and ST, and maturity offset. School-level predictors were more inconsistent but included of children on roll and playground area. Understanding school-level variables which influence PA would be useful for both schools and researchers who wish to increase school-based PA. The school environment is of great importance for PA promotion in children, which is exemplified by the UK government's aim for children to accrue 30 minutes of MVPA during the school day (HM Government, 2016). Future research should consider setting-specific PA and its correlates/predictors within specific school days contexts.

Thesis Study Map

Study	Objectives and Key Findings
Study 1: Predictors of Segmented School Day Physical Activity and Sedentary Time in Children from a Northwest England Low-Income Community	Objectives <ul style="list-style-type: none">• Establish the current MVPA and ST levels of children aged 9-10 years who attend schools in a low-income town of Northwest England.• Investigate the child and school-level influences on children's PA and ST during segmented school hours. Key Findings <ul style="list-style-type: none">• On average both boys and girls did not achieve the recommended 60 min of MVPA on average. School-based PA interventions are warranted.• Significant child-level predictors were maturity offset, CRF, weight status, WtHR, ST, and MVPA.• Significant school-level predictors were number of children on roll and playground area.
Study 2: Acceptability and feasibility of single-component primary school physical activity and sedentary behaviour interventions to inform the AS:Sk Project	Objectives <ul style="list-style-type: none">• Investigate the feasibility and acceptability of single-component school-based PA interventions.• Investigate the effectiveness of single-component school-based PA interventions on the levels of school-based MVPA and ST.
Study 3: Evaluation of a Pilot School-Based Physical Activity Clustered Randomised Controlled Trial — Active Schools: Skelmersdale	
Study 4: The process evaluation of Active Schools: Skelmersdale: a pilot school-based physical activity clustered randomised controlled trial	

**Chapter 5 (Study 2): Acceptability and feasibility
of single-component primary school physical
activity and sedentary behaviour interventions to
inform the Active Schools: Skelmersdale Project**

This study is currently under peer-review in the Journal of Physical Activity and Health.

Taylor, S. L., Noonan, R. J., Knowles, Z. R., McGrane, B., Curry, W. B., & Fairclough, S. J. (*In Review*). Acceptability and feasibility of single-component primary school physical activity and sedentary behaviour interventions to inform the AS:Sk project. *Journal of Physical Activity & Health*.

5.1 Author Contribution

S.T. designed the intervention components and the resources schools received. S.F. established the relationship with Les Mills fitness company who provided the Born To Move videos. S.T. carried out preparations for data collection, including the set-up of accelerometers and the design of interview guides. S.T. collected the data with assistance from WLSP coaches and undergraduate students from Edge Hill University. S.T. conducted the child group interviews and teacher interviews, with assistance from undergraduate students to conduct the child group interviews. S.T. inputted all the data and downloaded the raw PA data. S.T. transcribed the qualitative data with assistance from undergraduate students. S.T. conducted the full analyses of the data. Z.K. and R.N. aided with the analyses of qualitative data. S.T. wrote the manuscript. W.C., B.M., Z.K., R.N., and S.F. provided comments on the manuscript and read and approved the final version of the manuscript.

5.2 Introduction

Chapter 4 (Study 1) established that overall PA levels of children living in the high deprivation target area were low across the whole day and school day, thus confirming that interventions targeting various parts of the school day were warranted. The

segmented analysis of the school day including morning break, lunch break, and also PE was done in an attempt to potentially highlight specific areas of the school day which were more in need of intervention than others. However, given that PA was low overall there were no specific periods of the school day which were most in need of intervention. Furthermore, the significant predictors of Study 1, in particular the school-level measures would have been useful for the design of future interventions. Number on roll inconsistently predicted ST and PA, and playground area would be beyond the scope of the AS:Sk project to modify. Resultantly the significant predictors did not inform the design of future interventions.

The findings of study 1 are also supportive of previous research which has highlighted the need for school-based PA strategies (Kohl et al., 2012). In particular, whole-school approaches which are multi-component, thus engineering a range of PA opportunities into the day using a variety of strategies across different school settings are advocated (Fox et al., 2004). Nonetheless, it has been reported that multi-component interventions are difficult to implement and schools may not implement the interventions as intended as they struggle to follow and implement all strategies of a multi-component intervention (Okely et al., 2017). The use of frameworks such as the TEO designed to help interventions identify appropriate targets across different settings and contexts (Beets et al., 2016) can help to design more feasible interventions which are resultantly more attainable for schools to achieve and implement. Moreover, formative research is important to better understand the context-specific needs of different schools. Before implementing complex multi-component PA interventions, investigating the suitability of individual components

may first be warranted to understand their feasibility and acceptability in specific school contexts. This reflects the UK MRC best practice for implementing complex interventions, which recommends a phased approach with a feasibility stage testing for acceptability (Craig et al., 2008).

The increasing demands upon teachers and school staff to cover curriculum content and achieve academic targets should be considered alongside feasibility and acceptability aspects. Teachers have previously reported lack of time as a key barrier to implementing daily PA (Weatherson et al., 2017), despite expressed willingness from teachers to use PA to improve learning (van den Berg et al., 2017). School-based PA interventions need to be effective at increasing PA levels but also need to be suitable for use within a time constrained school day. Acceptability and feasibility of interventions should therefore be examined with the experiences and views of key agents such as teachers and children explored through qualitative methods (Laine, Araujo-Soares, Haukkala, & Hankonen, 2016; Moore, Audrey, Barker, Bond, Bonell, Hardeman, et al., 2015). The primary aim of this study was to explore the acceptability and feasibility of three brief single component primary school PA interventions. The secondary aim was to examine the impact of the interventions on levels of PA and ST. The findings will be used to evaluate the suitability of the interventions with a view to them being subsequently integrated within a multi-component intervention as part of the AS:Sk project.

5.3 Study-specific methods

5.3.1 Participants

Participating schools received the relevant paperwork to invite all Year 5 children ($n = 237$) to participate in the study. Through a combination of passive and active parental consent, and child assent completed prior to data collection, a sample of 225 children aged 9–10 years were recruited to participate (109 girls, 95% participation rate).

5.3.2 Interventions

Following the collection of data in Study 1, all participating schools were invited to project meetings to review the results (7-day accelerometry data) and discuss the implementation of a four-week PA intervention. Staff from the participating schools who attended meetings included head teachers, deputy head teachers, Year 5 teachers, and PE co-ordinators. A list of six potential interventions for Study 2 were presented to schools from which they were given the opportunity to select one which aligned best to the areas of their school day which they felt were most in need of intervention. Intervention approaches were to be implemented for four weeks and designed to have no financial cost to the project or schools to implement. The interventions proposed included: activity promoting pedagogical practices and training for PE, playground supervisory staff training for PA with activity ideas, changes to recess policies or rules (e.g., increase in time available), ABs, daily walking or running club, daily Born To Move videos (BTM; <http://www.lesmills.com/borntomove>).

Three schools implemented ABs. Twenty-three activity cards were created with pictures on the front demonstrating the activity and instructions on the back for

teachers to read out to children. All activities were suitable for use within the restricted space of a typical classroom and teachers were instructed to ensure any bags or other obstacles were not on the classroom floor whilst ABs were performed. Each activity card was designed to last for 30 seconds with ABs recommended to last for five minutes in total. This time period was chosen to minimise disruption to class time and has been used in a pilot of a primary school AB programme (ACTI-BREAK) (Watson, Timperio, Brown, & Hesketh, 2017). Teachers were advised to either select five activity cards completed twice, or 10 activity cards completed once. Teachers could perform an AB for shorter or longer periods if they wished and they were asked to implement at least one AB per day. A recent review of classroom-based PA interventions has reported small increases in PA through the use of ABs as well as positive impacts on academic outcomes (Watson, Timperio, Brown, Best, & Hesketh, 2017).

Two schools chose to implement daily BTM structured exercise videos. It was recommended that videos were used as a break to timetabled classroom learning and therefore not used as a substitute for PE. Videos were 10 minutes in duration and required hall/gym space with a projector screen. Videos included age-appropriate, Les Mills-instructor led motor skills set to contemporary music designed to improve health-related and skill-related fitness. A recent evaluation of the BTM pilot programme concluded that live 30-minute BTM lessons delivered by a trained instructor engaged children in significantly more MPA than during regular PE lessons (Fairclough, McGrane, et al., 2016).

The two remaining schools chose a training session for playground supervisory staff. Teachers who have previously engaged in PA-based professional development have reported it to be highly valued (Till, Ferkins, & Handcock, 2011). The training session lasted for 60-90 minutes and was delivered by the lead author and a PE professional development specialist from West Lancashire Sport Partnership, which delivers PA programmes in the participating schools. Training covered ideas for engaging less active children on the playground, and the importance of PA for health, wellbeing, and learning. Schools were provided with booklets of active games which required little or no equipment and were easy to set up. Examples of the games were delivered within the training session to demonstrate their simplicity. Playground supervisory staff were asked to implement active games daily and although they were made aware that the project was targeting children aged 9-10 years, they were told not to exclusively target these children on the playground. Given that the other intervention approaches of this study exclusively target Year 5 only, it was considered that the playground supervisory staff could also do this and exclusively target Year 5 when implementing the playground games. However, the decision to not ask playground supervisory staff to do this was based on pragmatic reasons. Playground breaks include children of all ages and asking a supervisor to tell other children who may wish to participate and be physically active that they cannot take part because they were perhaps too young or too old seemed unfair to ask schools to implement.

5.3.3 Measures

5.3.3.1 Qualitative

All children who were present on the day of data collection took part in a group interview conducted on the same day ($n = 32$ group interviews) to explore their experiences of the school intervention. Given that the results of this study were to be used to inform the design of a future multi-component intervention, group interviews were conducted with all available children (rather than a sub-sample) to assess acceptability across every school. Additionally, group interviews were deemed more appropriate than focus groups to assess acceptability. Group interviews differ from focus groups in that they are a way to gather many opinions from individuals within a group setting with conversation largely dictated by the interviewer directed to each individual in the group (Coe, Waring, Hedges, & Arthur, 2017). Whereas focus groups are more interactive and the group itself may take the conversation in a direction which was not anticipated nor initiated by the researcher (Coe et al., 2017). Focus groups are useful for co-constructing new knowledge, and gauging opinion for example (Coe et al., 2017). Therefore, if the aim of the study had been to use children's opinion to design new intervention strategies for future interventions, focus groups may have been more appropriate. However, to gain an understanding of the intervention acceptability which had been implemented, it was important that the researcher could dictate questions to achieve this. It has also been said that focus groups may be less suitable for post- group assessment of interventions (Coe et al., 2017).

Group interview size was between five and seven children with allocations pre-determined by teachers, as this was the most convenient. Group interviews were conducted by the researcher who had previous experience of collecting qualitative data. Two research assistants (undergraduate students) were recruited to also conduct group interviews and were trained in interview techniques for use with the target age group. Research assistants were required in order to conduct the large number of group interviews completed. A semi-structured format using open ended questions ensured consistency across the interviews for each intervention. Questions included, “what did you like about the new activities?”; “was there anything you didn’t like about the activities?”; “how would you feel if your teacher decided to stop doing the activities with your class?”. The group interviews took place in a quiet area in the school where participants could be overlooked but not overheard and lasted 5-19 (mean = 10) minutes. Group interviews were recorded using a digital recorder and transcribed verbatim resulting in 392 pages of raw transcription data in total, Arial font, size 12, double spaced.

Six class teachers and eight playground supervisory staff who experienced implementing the interventions were interviewed by the researcher. Interviews were conducted as four individual interviews and three small group interviews. Group interviews were arranged for convenience, particularly for playground staff who were not full-time school staff. All participants were given the opportunity to respond to each question in turn regardless of whether they were in a group or individual interview and discussion within groups was not permitted. Semi-structured interview guides with open ended questions were used. Example interview questions included,

“how much planning was/is required to implement the intervention?”; “were there any barriers which prevented you from implementing the intervention on certain days?”; “do you think you would be able to sustain the intervention across a full school year?”; “is there anything you would need to be able to do so?”. The interviews took place in a quiet, private area of the school at a convenient time and lasted 6-22 (mean = 12.4) minutes. Teacher interview data consisted of 65 transcript pages.

5.3.3.2 Quantitative – Device-Based Physical Activity Measures

During the final week of the four-week intervention period children wore an accelerometer. Limited availability of accelerometers meant that a combination of ActiGraph GT9X (AG; Pensacola, FL, USA) and GENEActiv (GA; Activinsights, Cambs, UK) devices were used (AG $n = 93$, GA $n = 132$). Consistency of accelerometer devices within schools was possible, however consistency of accelerometer devices within intervention type was not possible. Agreement between the GA and AG devices has been investigated, with results indicating that AG accelerations were 9-11% lower than GA for the same activities, but that time spent in ST and LPA thresholds was statistically equivalent (Rowlands, Mirkes, et al., 2018). Furthermore, although not within the 10% equivalence zone, agreement between the devices for MVPA was high (Rowlands, Mirkes, et al., 2018). As the primary focus of this study was on intervention acceptability and feasibility, rather than activity levels, a decision was made to combine AG and GA data, while at the same time acknowledging the associated equivalency issues. Both devices were initialised to record raw accelerations at a frequency of 30Hz. Weekdays with wear time of at least 10 hours were included and children with three or more valid days were included in school week averages. This

wear time inclusion criterion has previously been used in research exploring school day and segmented school day PA levels (Mooses et al., 2017; Nettlefold et al., 2011).

Published ENMO prediction equations were used to identify cut-points for classifying activity as MVPA (child-specific 3 METs) (Hildebrand et al., 2014). As there is no consensus as to the most appropriate ENMO ST cut-points (Hildebrand, Hansen, van Hees, & Ekelund, 2017), the Hildebrand et al. regression equations were applied using 1.5 METs, which resulted in values of 51 mg (AG) and 61 mg (GA). As GA acceleration outputs are typically 9-11% higher than AG we selected a comparable value of 50 mg for both devices as a cut-point to estimate ST. The ENMO cut-points used are displayed in Table 5.1.

Table 5.1 ENMO cut-points used.

	Sedentary Time	Light PA	Moderate PA	Vigorous PA
ActiGraph (mg)	0-49	50-200	201-706	707-8000
GENEActiv (mg)	0-49	50-191	192-695	696-8000

5.4 Analyses

5.4.1 Qualitative

Inductive thematic analysis (Braun & Clarke, 2006) allowed for themes to be identified and extracted from the child and teacher qualitative data driven by the aims of the research. Data from the children and teachers were analysed separately, but data from different schools was pooled by intervention type to allow for comparisons across each intervention group. The step-by-step guide set out by Braun and Clarke

(2006) was followed throughout the analysis, as outlined in Table 5.2. The group interviews in particular were analysed for individual accounts to explore acceptability and feasibility as opposed to consensus

Table 5.2. Detail of the steps taken to compete the inductive thematic analysis.

Step outlined by Braun & Clarke (2006)	Actions by lead researcher
1. Familiarisation with data	As outlined in the author contributions section, some transcriptions were completed by undergraduate student assistants. The lead researcher also completed transcriptions of the qualitative data. Once all transcriptions were completed they were read and re-read whilst checked against the audio recordings for accuracy. Notes were made on some initial codes, as the transcriptions were read analytically starting to consider what the data meant.
2. Generating initial codes	<p>Initial codes from the data were produced, which were of interest in relation to the aims of the study – acceptability and feasibility. These were words or brief statements which were created to explain why a particular section of data was of interest. Below are two examples of codes applied to short segments of data.</p> <p><i>“The songs they're like songs that we know so it's like what we enjoy so it's not like anything for adults. It's like kids music and things like that that kids are into so it's latest stuff.”</i></p> <ul style="list-style-type: none"> - Enjoyment/fun. - Music of the videos. - Appropriate for their age. - Modern. <p><i>“Where I sit we're all squished and when you do the star jumps I feel like people are gonna hit me.”</i></p> <ul style="list-style-type: none"> - Restrictions of the classroom. - Other children. - Limited classroom space.
3. Searching for themes	Once all the data was initially coded, potential themes were created by collating coded data extracts and considering how they could be combined. For example, within the ABs there were codes which related to singing whilst moving and moving to music. These were teacher-initiated additions to the ABs which became apparent from the qualitative data, therefore, these codes became a theme of “Variations”. Consistent across the BTM and ABs were codes of additional activity, additional exercise, health improvements, strength

or getting stronger. These subsequently became a theme of “Health improvement”. In the example given for stage 2, in which music of the BTM videos was coded, other codes relating to the videos included the dance moves. These two codes subsequently became a theme of “Session content”.

4. Reviewing themes
Refinement was to provide satisfaction that the final themes adequately captured the coded data. At this stage a second researcher (R.N) ensured consistency. This also allowed for alternative interpretations with cross-examination in reverse, from themes to codes to transcriptions. This process was repeated until an acceptable consensus had been reached (90% agreement level). Some themes were broken down into separate themes whilst it appeared that others did not have sufficient data to support them so they were removed. For example, ‘Something different’ was created as a theme within stage 3. After consultation with the second researcher a decision was made to remove this theme from within ABs as the theme was not self-defining and there was also insufficient clear data to support the theme.
 5. Defining and naming themes
Analysing the data within each theme. This stage allowed for determination of what each theme captured in relation to the study aims – acceptability and feasibility. Considering how each theme fitted into the broader overall ‘story’ meant that themes were considered in terms of whether the intervention components were suitable for use within a multi-component intervention and whether adaptations were required for future use.
 6. Producing the report
At this stage, sets of fully worked out themes were completed. The task of writing-up began with a decision to present the data via pen profiles. Given that this was a mixed-methods study, these pen profiles were selected as a way to illustrate key themes from the data presenting examples of key verbatim quotes and frequency data in a concise and efficient system. Recently, pen profiles have been used to present data in similar PA qualitative research outputs (Knowles, Parnell, Stratton, & Ridgers, 2013; Mackintosh, Knowles, Ridgers, & Fairclough, 2011; Noonan, Boddy, Fairclough, & Knowles, 2016). Furthermore, the decision to use pen profiles was influenced by considering publishing this work in a PA related journal which often includes a limited word count to abide by, particularly in comparison to psychological journals. Presenting the qualitative data within pen profiles does not require large proportions of a word count and allows for publication alongside quantitative data whilst adhering to any word count. Pen profiles were presented to two authors (R.N, Z.K) with previous experience in this analysis (Knowles et al., 2013; Noonan, Boddy, Fairclough, et al., 2016), to ensure accuracy.
-

5.4.2 Quantitative

A one-way ANOVA examined differences in MVPA and ST across the whole school day between each intervention component. For the AB and BTM interventions, teachers were asked to report the times during which the interventions took place each day across the 4-week implementation phase. Data were filtered using the *ilevels* parameters in GGIR to generate MVPA and ST values during the teacher-defined intervention times and during equivalent 'usual practice' classroom lessons which occurred directly before or after. The intervention time periods ranged from five to 15 minutes. To ensure all of the MVPA and ST accrued was included, 30-minute windows were used to include the intervention components. Children who had 10 hours of wear time on the reported intervention days were included, regardless of whether they had three valid weekdays of 10-hour wear time overall. Paired samples t-tests examined differences in MVPA and ST between intervention times and the usual-practice classroom times. This analytic approach was not suitable for use with the playground intervention data because there was no usual-practice comparator available. Instead, lunch-time playground data of schools participating in the playground intervention was compared to the other schools using teacher defined lunch playground times and independent t-tests. Statistical significance was set at 0.05 and effect sizes were represented by Cohen's *d*. Analyses were conducted using the statistical package SPSS (v.23, SPSS Inc., Chicago, IL, USA).

5.5 Results

One hundred and nineteen children took part in the AB for four weeks, 111 of these children took part in the group interviews, and three teachers were interviewed. Fifty

children took part in the BTM video intervention for four weeks, 48 of these children took part in the group interviews, and three teachers were interviewed. Fifty-six children took part in the playground intervention for four weeks, 52 of these children took part in the group interviews, and eight playground staff were interviewed.

5.5.1 Qualitative

5.5.1.1 Child Perceptions

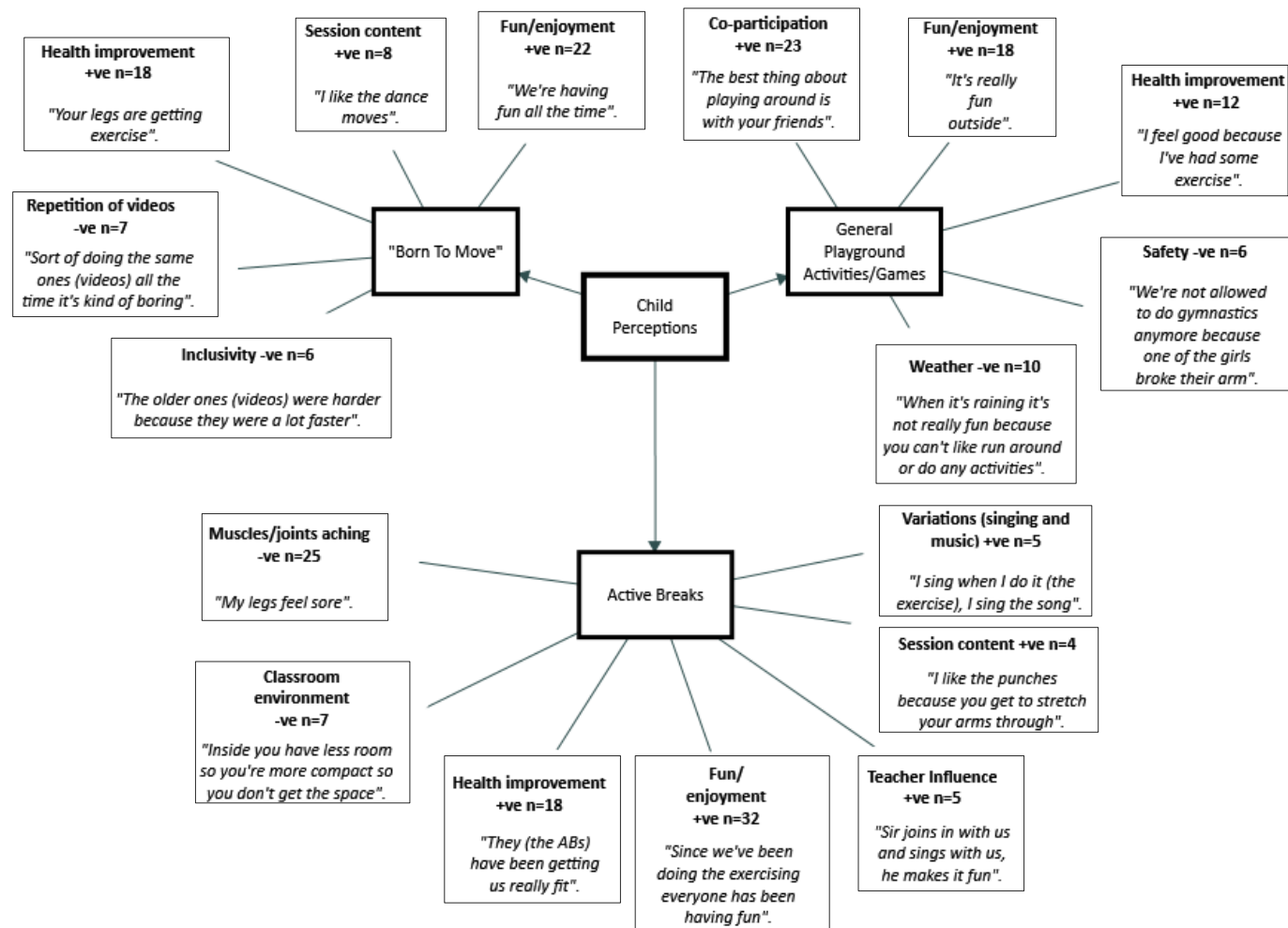
Pen profiles representing children's perceptions are presented in Fig. 5.1, with three higher order themes of each intervention (i.e., ABs, BTM, and playground). Positives (+ve; child reported likes) and negatives (-ve; child reported dislikes) of each intervention were the higher order sub-themes. There were nine sub-themes relating to ABs, which included, variations +ve (singing and music; $n=5$), session content +ve ($n=4$), health improvement +ve ($n=18$), teacher influence +ve ($n=5$), fun/enjoyment +ve ($n=32$), muscle/joints aching -ve ($n=25$) and the classroom environment -ve ($n=7$). There were five sub themes of BTM, which were health improvement +ve ($n=18$), session content +ve ($n=8$), fun/enjoyment +ve ($n=22$), video repetition -ve ($n=7$), and inclusivity -ve ($n=6$). There were five sub-themes for playground activities. However, these were in relation to general and traditional playground games/activities/sports and not the specific new teacher lead games of the intervention. Sub-themes included: co-participation +ve ($n = 23$), fun/enjoyment +ve ($n=18$), health improvement +ve ($n=12$), safety -ve ($n=6$) and weather -ve ($n=10$).

5.5.1.2 Teacher acceptability and feasibility

Pen profiles representing teacher acceptability and feasibility are presented in Fig. 5.2, again with three higher order themes of each intervention. Positive sub-themes

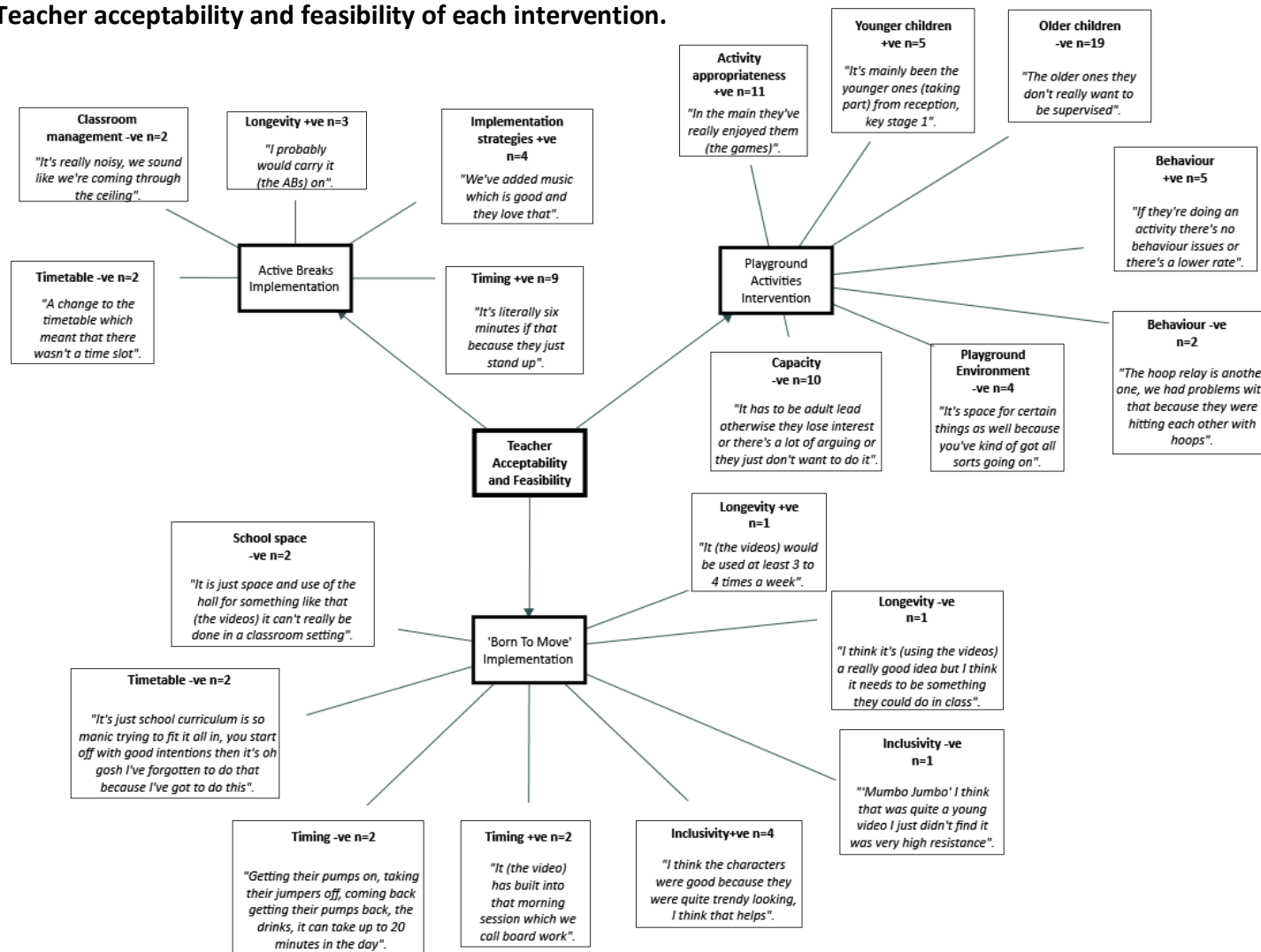
included useful methods for implementation and acceptability. Negative sub-themes included barriers towards implementation. There were five AB sub-themes, which were: longevity +ve ($n=3$), implementation strategies +ve ($n=4$), timing +ve ($n=9$), timetable -ve ($n=2$), and classroom management -ve ($n=2$). Teachers who implemented BTM reported eight sub-themes of: timing +ve ($n=2$), inclusivity +ve ($n=2$), longevity +ve ($n=1$), timing -ve ($n=2$), inclusivity -ve ($n=2$), longevity -ve ($n=1$), school space -ve ($n=2$), and timetable -ve ($n=2$). When discussing the playground games that playground supervisory staff were asked to implement, seven sub-themes were, activity appropriateness +ve ($n=11$), younger children +ve ($n=5$), behaviour +ve ($n=5$), older children -ve ($n=19$), behaviour -ve ($n=2$), playground environment -ve ($n=4$), and capacity -ve ($n=10$).

Figure 5.1. Children's perceptions of each intervention.



+ve = positive. -ve = negative.

Figure 5.2. Teacher acceptability and feasibility of each intervention.



+ve = positive. -ve = negative.

5.5.2 Accelerometer Data

One hundred and ninety-five children (87% compliance) wore an accelerometer for the defined wear time to establish school day ST and MVPA levels (Table 5.2). There were significant differences in whole school day MVPA levels between children who received the AB and BTM ($p<.001$, $d=-0.9$), and BTM and playground ($p=.007$, $d=0.6$) interventions. Significant differences in whole school day ST levels between children who received the AB and BTM ($p<.001$, $d=0.7$), and AB and playground ($p<.001$, $d=1$) interventions were also observed.

5.5.2.1 Active Breaks

Twelve ABs were analysed. Teachers typically implemented ABs once a day in the morning for five minutes. Some teachers did report implementing two ABs a day, however this was less common (average = five days across the four weeks). There were only three days across the three schools (one in each) that ABs were not implemented. The average ST and MVPA times during 30-minute windows including ABs and the comparative 'usual practice' class time are presented in Table 5.3. There were 4.8 minutes of MVPA accrued on average during ABs, which was significantly higher than during 'usual practice' ($p<.001$, $d=2.2$). ST during ABs was significantly lower (20.3 minutes) than during 'usual practice' lessons (25.3 minutes; $p=.009$, $d=-1.0$).

Table 5.3. Whole school day ST and MVPA by intervention component trialled (Mean and Standard Deviation).

	AB Intervention (<i>n</i> =101)	BTM Intervention (<i>n</i> =43)	Playground Intervention (<i>n</i> =51)	AB vs. BTM	AB vs. PI	BTM vs. PI
ST (minutes)	259.9 (30.6)	237.0 (33.4)	232.9 (25.7)	<i>p</i> <.001 <i>d</i> =0.7	<i>P</i> <.001 <i>d</i> =1.0	<i>p</i> =0.8 <i>d</i> =0.1
MVPA (minutes)	32.3 (13.0)	45.7 (15.6)	37.0 (14.2)	<i>p</i> <.001 <i>d</i> =-0.9	<i>p</i> =0.8 <i>d</i> =-0.3	<i>p</i> =0.007 <i>d</i> =0.6

Table 5.4. ST and MVPA accrued during 30-minute windows including an AB, BTM video and usual classroom practice (Mean and Standard Deviation).

	AB	'Usual practice' pre/post AB	<i>P</i> value	<i>D</i> value	BTM	'Usual practice' pre/post BTM	<i>P</i> value	<i>D</i> value
ST (minutes)	20.3 (5.4)	25.3 (4.4)	0.009	-1.0	12.5 (5.2)	21.3 (4.7)	0.003	-1.8
MVPA (minutes)	4.8 (2.5)	0.9 (1.1)	<.001	2.2	8.6 (4.0)	1.8 (2.6)	0.002	2.1

5.5.2.2 Born To Move

BTM videos were implemented during mornings, afternoons, and just before the end of the school day. One school consistently implemented the videos every day, but implementation was infrequent in the other school. In total, seven BTM video PA sessions were analysed. ST and MVPA times during 30-minute windows including the BTM videos and the comparative 'usual practice' are presented in Table 5.4. MVPA during BTM videos (8.6 minutes) was significantly higher compared to 'usual practice' (1.8 minutes; $p=.002$, $d=2.1$). ST during BTM videos (12.5 minutes) was also significantly lower than during 'usual practice' (21.3 minutes; $p=.003$, $d=-1.8$).

5.5.2.3 Playground Intervention

Lunchtime playground ST and MVPA are presented in Table 5.4. On average, time on the playground at lunch was 37 minutes (range 25-45 minutes). Within the playground intervention schools, %ST was significantly lower (35.4) in comparison to the other schools (43.8, $p<.001$, $d=-0.7$). Lunchtime playground MVPA during the playground intervention schools was 17.2%, compared to 14.6% ($p=.08$, $d=0.3$).

Table 5.5. Percentage ST and MVPA accrued during lunch-time break of the schools participating in the playground intervention and the other remaining schools (Mean and Standard Deviation).

	Playground intervention schools ($n=2$)	Other schools ($n=5$)	<i>P</i> value	<i>D</i> value
Playground %ST	35.4 (9.1)	43.8 (16.2)	<.001	-0.7
Playground %MVPA	17.2 (7.5)	14.6 (9.5)	0.08	0.3

5.6 Discussion

The primary aim of this study was to explore the acceptability and feasibility of four-week single component school-based PA interventions with a view to them subsequently being integrated into a multi-component intervention. All participating schools were able to implement the interventions but highlighted a range of implementation challenges. These related to space and the school environment, as well as the competing demands of teachers and other members of staff, such as timetable constraints and other responsibilities. The secondary aim to examine the impact on levels of PA and ST, indicated some positive effects particularly in the AB and BTM interventions.

5.6.1 Acceptability and feasibility

There are inconsistent findings about the relationship between teacher supervision and children's active play on school playgrounds (Hyndman, Benson, & Telford, 2016). In the present study, when asked about new teacher-led playground activities or games, none of the children in the participating schools reported taking part. Teachers agreed with these reports from the participating children. Teachers stated that the activities and games could be implemented with younger children (ages five to seven years), but a number of barriers prevented involvement from older children (age groups of those who participated in the study). Recess-focussed PA research has studied age with inconclusive results (Ridgers, Salmon, et al., 2012). Teacher-reported barriers included: the older children not wanting supervision or structure. "Mostly the older ones they play football, I guess they don't like the structured approach so much because they're becoming a bit more independent, they want to be doing things on

their own I think” (Teacher from playground activity intervention school). Despite the training received, teachers still found it challenging to engage students in activities. Previous research has reported similar issues, relating to time constraints and difficulties with participation in playground activities whilst maintaining responsibilities to monitor the playground at the same time (Parrish, Yeatman, Iverson, & Russell, 2012; Smedegaard, Brondeel, Christiansen, & Skovgaard, 2017). Teachers argued the need for activities which children could engage in independently. Behavioural issues (e.g., arguments) or health and safety issues (e.g., administering first aid) commonly required teacher attention and prevented adult-led activities from being sustained. “Sometimes you’ll get an issue that needs dealing with so you’re pulled off you know if there’s a first aid issue or I don’t know somebody has fallen out with somebody you have to go and sort it out” (Teacher from playground activity intervention school).

Enjoyment and health enhancements were themes from all participating children across the different interventions. Enjoyment is deemed to be a crucial factor in health behaviour change research of children as it is a stable and consistent psychological construct which predicts PA participation and adherence (Best et al., 2017; Gebremariam et al., 2012; Teixeira, Carraça, Markland, Silva, & Ryan, 2012). Child enjoyment of integrating movement into classrooms has also been previously reported (Martin & Murtagh, 2017c). Thus, the children’s consistent and common reports of enjoyment, for particularly the AB and BTM interventions, increase the acceptability of these interventions for further use. “The active breaks are really fun” (Child from AB intervention school). “You just enjoy having a like move around” (Child

from BTM intervention school). Children reporting exercise participation and health enhancement provides a link to the predisposing factors described in the Youth PA Promotion Model (Welk, 1999). Children in the current study recognised the perceived benefits of the additional PA to their day, which further reinforces the acceptability of the interventions. “Taking part makes you get fitter” (Child from BTM intervention school).

A reported child dislike of the ABs was lack of space which was also recognised by teachers. “Inside you have less room so you’re more compact so you don’t get the space” (Child from AB intervention school). “A bit more room would help” (Teacher from AB intervention school). In other AB research, space has been reported as a consideration for implementation (McMullen et al., 2014). However, and again similar to the previous research (McMullen et al., 2014), teachers in the current study did not report lack of space as something which would prevent them from implementing the ABs, but rather something they needed to consider and subsequently adapt the activity around. “There's normally bits of space in different places so I will just move them to that space” (Teacher from AB intervention school). Teachers talked about positive adaptations and implementation strategies that they were able to use to ensure the ABs were compatible with the practice of participating classes. Strategies included incorporating learning and academic content, “I introduced it into my Maths lessons and we did some mental maths, orally rehearsing, recalling facts as well as completing the exercises” (Teacher from AB intervention school). Giving children extra challenges, “I kind of made a bit of a game with them now so if they’re not putting that effort in or if they stop half way through the 30 seconds I’ll say right we’re adding

another 10 seconds on because so and so stopped” (Teacher from AB intervention school). Also, participation with music playing, and allowing the children to choose the activity cards rather than this being a teacher decision, “The VIPs got to pick every exercise that we did. It makes me feel excited because you get to pick the ones that you're used to and you can pick new ones that you've not learned yet.” (Chid from AB intervention school). Previous research has suggested that when teachers see positive attributes and outcomes of PA they adopt their own strategies which help movement and PA to be truly integrated into classroom life (Webster et al., 2017). Integration is particularly important due to the well reported time constraints within schools (Weatherson et al., 2017). Time in relation to the ABs was talked about positively by participating teachers, stating that overall implementation and transitions to learning afterwards were quick. “They know straight away, stand up find a space and they do it and then it's sit back down and they're ready to learn” (Teacher from AB intervention school). This is supportive of recent recommendations for practice stating that classroom-based PA should have a minimum duration of 10 minutes (van den Berg et al., 2017). Although, unexpected changes to the timetable or particularly busy days could still prevent ABs from being implemented in the current study. “We missed one because of a difference in timetabling so it wasn't the fact that we hadn't thought about it we just couldn't physically fit it in because of the change to the day.” (Teacher from AB intervention school).

The longer duration of BTM videos (up to 20 minutes) was acknowledged by teachers as a barrier to implementation, since this time period included getting to and from the hall/gym as well as participation in the video. This was seen as a considerable amount

of time to take away from a busy school curriculum. However, one teacher talked positively in relation to timing, stating that the videos had been integrated into and fitted well into their morning session. Previous research has reported goals and behavioural regulation to be facilitators of school-based PA, such as planning for and scheduling PA into the timetable (Weatherson et al., 2017). A further barrier to the implementation of the BTM videos was the need for participation to take place in the school hall/gym. “You have to wait for the hall to be free” (Teacher from BTM intervention school). This area within UK schools is used regularly for activities such as assemblies, PE lessons, and commonly doubles as a dining room at lunch time. This would support recently published feasible strategies for PA in schools which stated that implementation should take place in the classroom (van den Berg et al., 2017). This is primarily due to scheduling and timetabling issues in which access to the hall/gym cannot always be guaranteed at a time which suits the teacher (van den Berg et al., 2017). Furthermore, more time is needed to get children to and from classrooms and halls/gyms.

5.6.2 MVPA and sedentary time

MVPA during 30-minute windows of the school day which included an AB was significantly higher than the comparable 30-minute windows of ‘usual practice’ classroom learning. Findings from previous classroom AB research have also demonstrated the effectiveness of this approach for increasing PA levels. In a study of six schools, minutes/day of ABs was positively associated with students’ MVPA, and students were more likely to achieve the recommended 30minutes/day of MVPA during school hours if their teachers reported implementing ABs (Carlson et al., 2015).

There were 4.8 minutes of MVPA accrued on average during the 30-minute windows of school time which included participation in an AB. In comparison, there were 8.6 minutes of MVPA accrued on average during the 30-minute windows including participation in a BTM video. Whilst the videos were implemented for longer than the ABs (10 minutes compared to five minutes), they were also implemented in the school hall/gym. Although mentioned previously as a barrier towards implementation, children participating in the BTM videos were resultantly provided with increased space in comparison to the classroom environment. During the recess period of the school day, although within a different location of outdoors compared to the school hall/gym, available play space per child has been found to predict increased vigorous PA and decreased ST (Ridgers, Fairclough, et al., 2010). Overall, MVPA was highest on average in the schools participating in the BTM intervention.

In all participating schools percentage time spent in MVPA on the playground was lower than the 30% to 35% figures previously reported through accelerometers, regardless of the intervention implemented (Nettlefold et al., 2011). Previous school-based recess interventions have largely focused on changing the physical environment of playgrounds, for example with markings and equipment (Chin & Ludwig, 2013; Erwin et al., 2014). More similar to the current intervention, previous studies have implemented playground age-appropriate games and activities. For example, in the 'Recess Enhancement Program' external play coaches visited schools twice a week and encouraged teachers to facilitate games in the coach's absence (Chin & Ludwig, 2013). Conversely, trained researchers have been used to implement structured recess games (Howe, Freedson, Alhassan, Feldman, & Osganian, 2012). Whilst both studies

found positive effects on MVPA outcomes, their sustainability could be questioned (Chin & Ludwig, 2013; Howe et al., 2012). To have an external qualified coach across a whole school year would be a costly addition for schools. More sustainable approaches with minimal or less financial impact are warranted to improve recess MVPA in the long-term. In terms of percentage ST on the playground, this was significantly lower in the playground intervention schools in comparison to the other participating schools. Although it is difficult to speculate why this was, given the perceived lack of take-up by the target children which was highlighted within the qualitative data.

5.6.3 Strengths and Limitations

A strength of the current study is the triangulation of data. Triangulation refers to a process whereby two or more methods of data collection or sources of data are used, in order to get as close to the 'truth' of the object of a study as possible (Braun & Clarke, 2013). Thus, collecting data from the perspective of participating children and teachers, in addition to accelerometer data provides robust evidence of each intervention's acceptability and feasibility. This approach is consistent with the MRC's guidance for developing and evaluating complex interventions, which advocates the combined use of qualitative and quantitative methods when assessing feasibility (Craig et al., 2008). Additionally, investigator triangulation which involved the participation of three researchers in total within the study allowed for alternative perspectives to be presented, providing multiple observations and conclusions (Carter et al., 2014). This ensured methodological rigor and credibility whilst the comparison of pen profiles with verbatim data accentuated dependability (Cope, 2014).

Limitations include the short implementation period of four weeks. A pragmatic approach was needed in the wider context of the AS:Sk project in which a staggered start four-week implementation period across the seven schools was most suitable. Additionally, the use of different accelerometer models (AG and GA) was a limitation. Comparisons between MVPA outcomes should be made with caution due to the technical differences between the accelerometers used, with GA values typically higher than AG, particularly for MVPA (Rowlands, Mirkes, et al., 2018). There are also limitations to the qualitative data collected. Whilst the number of group interviews conducted ($n = 32$) is a strength. This required the assistance of undergraduate students who despite receiving basic training, may have struggled to elicit detailed answers from children due to their inexperience. Furthermore, overall the group interviews were short in length due to limited time available in schools to get through data collection with every child. Given that the aim of the group interviews was to gain an understanding of acceptability of interventions from the point of view of the children, a detailed and deeper understanding of children's thoughts or perceptions was not necessary in order to achieve this aim. A limitation of the playground intervention in particular is that it did not exclusively target Year 5 participating children as the other intervention approaches did so. Furthermore, as a result of missing recording sheets and unavailable 'usual practice' directly before or after, a limited number of AB ($n=12$) and BTM ($n=7$) intervention periods were extracted for analysis of the MVPA and ST data.

5.7 Conclusions

ABs are a feasible and acceptable intervention which result in increased MVPA during the school day. Teachers were able to implement ABs regularly and children reported them enjoyable to take part in. BTM videos or similar high intensity instructional exercise videos, are less feasible to implement on a daily basis. Whilst these interventions also led to engagement in MVPA and children found them enjoyable, access to sufficient space for implementation was cited by teachers as a challenge. This type of intervention may be more feasible to implement on a less regular basis, for example two-three times per week. Playground staff reported that they found it challenging to implement activities or games due to their competing role responsibilities. Staff also reported differences between the engagement of younger and older children and perceived older children to prefer independence. Based on this feedback, games or activities which could be undertaken independently by children without the need for teacher initiation or support, whilst ongoing, may be more feasible to implement. Future research should assess the feasibility and acceptability of these example interventions when implemented simultaneously in a multi-component intervention, in which they may consequently have the greatest potential for impacting MVPA levels.

Thesis Study Map

Study	Objectives and Key Findings
Study 1: Predictors of Segmented School Day Physical Activity and Sedentary Time in Children from a Northwest England Low-Income Community	<p>Objectives</p> <ul style="list-style-type: none">• Establish the current MVPA and ST levels of children aged 9-10 years who attend schools in a low-income town of Northwest England.• Investigate the child and school-level influences on children's PA and ST during segmented school hours. <p>Key Findings</p> <ul style="list-style-type: none">• On average both boys and girls did not achieve the recommended 60 min of MVPA on average. School-based PA interventions are warranted.• Significant child-level predictors were maturity offset, CRF, weight status, WtHR, ST, and MVPA.• Significant school-level predictors were number of children on roll and playground area.
Study 2: Acceptability and feasibility of single-component primary school physical activity and sedentary behaviour interventions to inform the AS:Sk Project	<p>Objectives</p> <ul style="list-style-type: none">• Investigate the feasibility and acceptability of single-component school-based PA interventions.• Evaluate the effectiveness of single-component school-based PA interventions on levels of school-based MVPA and ST. <p>Key Findings</p> <ul style="list-style-type: none">• Implementation challenges related to space within the school environment, competing demands of teachers and other members of staff, such as timetable constraints and other responsibilities.• The AB and BTM interventions indicated positive effects on levels of MVPA and ST.

Study 3: Evaluation of a Pilot School-Based Physical Activity Clustered Randomised Controlled Trial — Active Schools: Skelmersdale	Objectives <ul style="list-style-type: none"> • Evaluate the effectiveness of the AS:Sk multi-component intervention on levels of school-based MVPA and ST.
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Study 4: The process evaluation of Active Schools: Skelmersdale: a pilot school-based physical activity clustered randomised controlled trial

**Chapter 6 (Study 3): Evaluation of a Pilot School-
Based Physical Activity Clustered Randomised
Controlled Trial – Active Schools: Skelmersdale**

This study has been published in the International Journal of Environmental Research and Public Health and can be found in Appendix 4.

Taylor, S. L., Noonan, R. J., Knowles, Z. R., Owen, M. B., McGrane, B., Curry, W., B., & Fairlcough, S. J. (2018). Evaluation of a Pilot School-Based Physical Activity Clustered Randomised Controlled Trial—Active Schools: Skelmersdale. Int J Environ Res Public Health, 15(5). doi: 10.3390/ijerph15051011

6.1 Author Contribution

S.T. designed the intervention components and the resources schools received. S.F. established the relationship with Les Mills fitness company who provided the Born To Move videos. S.T. carried out preparations for data collection, including the set-up of accelerometers. S.T. collected the data with the contribution of M.O., WLSP coaches and undergraduate students. S.T. inputted all the data, downloaded the raw PA data, and conducted the full analyses of the data. Training on statistical analysis was received from S.F. S.T. wrote the manuscript. R.N., Z.K., M.O., B.M., W.C., and S.F. provided comments on the manuscript and read and approved the final version of the manuscript.

6.2 Introduction

Chapter 5 (Study 2) provides formative research for the further school-based PA strategies which are investigated in the current chapter. The current study progresses the work of Chapter 5 (Study 2) by implementing a multi-component intervention in comparison to single-component strategies targeting only one area of the school day. A comprehensive intervention perspective with a focus on multiple-level factors

exemplifies a socio-ecological approach (McLeroy et al., 1988). Action Schools! BC is an ongoing example of an intervention underpinned by the socio-ecological model (Naylor, Macdonald, Reed, et al., 2006), and which resulted in PA increasing through activities implemented across six different school components named 'action-zones' (Naylor, Macdonald, Zebedee, et al., 2006). Literature reviews have further supported this approach to intervention design, stating that interventions targeting different levels of the socioecological model and those that are multi-component in nature can have a positive impact on PA levels (Kellou et al., 2014; Murillo Pardo et al., 2013; Owen et al., 2017; van Sluijs et al., 2007).

That being said, multi-component interventions are not always successful at increasing PA (Okely et al., 2017; Van Kann et al., 2016). Multi-component interventions are difficult to put into practice and a lack of implementation, with schools not implementing as intended, has previously been reported (Okely et al., 2017). More recently, a more pragmatic approach to PA promotion has been proposed which includes the expansion, extension, and enhancement of PA opportunities (TEO) (Beets et al., 2016). The use of this approach allows researchers to target various levels within an ecological model but additionally, and importantly, identify appropriate targets (Beets et al., 2016).

The AS:Sk pilot multi-component clustered RCT was designed to promote PA across the school day through multiple opportunities which could be integrated into every day school life and implemented by school staff. The aim of this study was to evaluate the impact of the AS:Sk intervention on children's MVPA. Secondary outcome measures included ST and health indicators.

6.3 Study-specific methods

6.3.1 Participants

The required number of participants was determined using a sample size calculation that accounted for the pre-determined number of schools (Hemming, Girling, Sitch, Marsh, & Lilford, 2011). For the intervention group to achieve 30 minutes school day MVPA, based on Chapter 4 (Study 1) findings (Taylor et al., 2017) a mean difference in school day MVPA of 12.5 minutes between the control and intervention groups would need to be detected. This difference requires an alpha level of 0.05 and power of 90% while assuming a standard deviation of 8.6 minutes, in a clustered randomised design with seven clusters (schools). Based on these parameters a minimum of 100 participants (50 per group) were required (based on 15 participants per cluster and assuming an intracluster correlation of 0.04) (Hemming et al., 2011). Assuming a 30% dropout per school, seven schools were recruited with a minimum of 20 participants per school to account for this anticipated rate of attrition. Thus, all children within Year 5 (ages 9-10 years) of each participating school were invited to take part in the study ($n = 239$). Through passive parental consent in six schools, and active parental consent in one school, 232 children were recruited to participate (97% recruitment rate; Control $n = 115$, Intervention $n = 117$).

6.3.2 Study Design

Following the collection of baseline measurements, the names of each participating school were written onto individual pieces of paper, folded, and sealed. The Associate Head of the Sport and Physical Activity Department, who had no association with the project, was asked to select four of the sealed pieces of paper for the intervention

condition. The remaining three schools were subsequently assigned to the control condition. This randomisation was not blinded due to the nature of the intervention. There was a one-week gap between the allocation of groups and the beginning of the intervention period to allow for the teachers to plan and organise intervention components into their future school plans. Control schools were informed via email of their selection and agreed to continue with their usual timetabled amount of playground breaks and PE lessons without any additional time allocated for PA participation. Details of the flow of participants through the study from baseline to follow up are provided in Figure 6.1. As shown in the analysis stage of Figure 6.1, only participants that had full datasets at both baseline and follow-up were included, which subsequently impacted the total number of included participants. Intention-to-treat analysis can preserve sample size but estimate of treatment effect is generally conservative and has been criticised for being too cautious, therefore a decision was made not to take this approach (Gupta, 2011). Moreover, heterogeneity might be introduced if non-compliant, dropouts and compliant subjects are mixed together in the final analysis (Gupta, 2011).

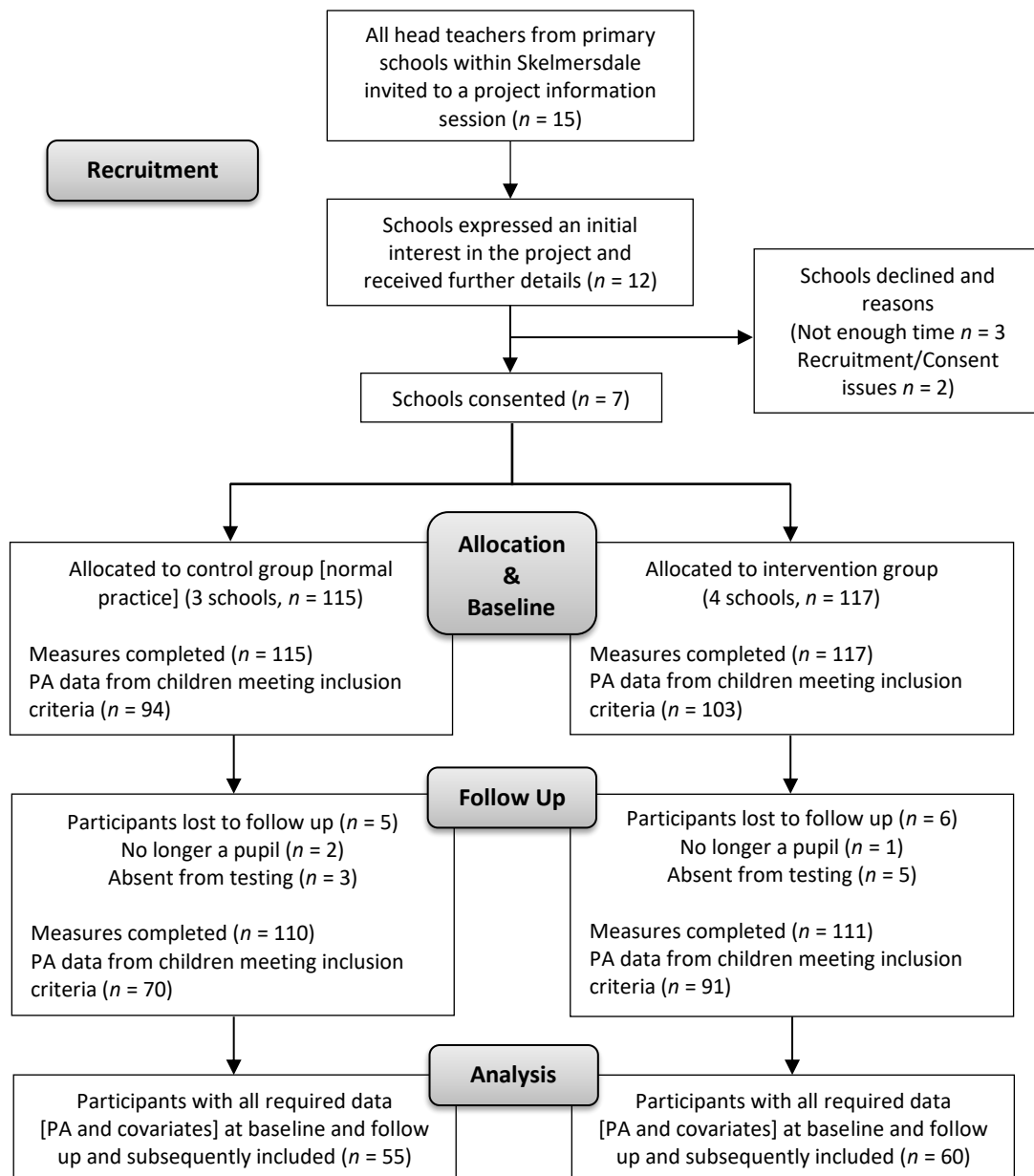


Figure 6.1. Flow of schools and participants through the study.

6.3.3 Intervention

The CONSORT guidelines extension for clustered randomised controlled trials (Campbell, Piaggio, Elbourne, & Altman, 2012) were followed for reporting the results of the AS:Sk project, which was a cluster RCT of an eight-week multi-component school-based PA intervention. The intervention consisted of eight components: ABs, bounce at the bell, BTM videos, Daily Mile (DM) or 100 Mile Club (MC), playground

activity challenge cards, PE teacher training, newsletters, and activity homework. All intervention approaches were designed to have no cost to the project or schools to implement. Intervention schools were provided with a written guide to each intervention component and class teachers met with the project lead to discuss and have any questions they had answered. The recommended minimum duration and implementation frequency per school day or week was provided for each component, which teachers were asked to follow as closely as possible. Schools were given the freedom to implement the components when it best suited their own timetable and they could increase frequency if they wished to do so.

A description of each intervention component with the recommended duration and frequency per school day or week is presented in Table 6.1. The components were selected based on the previous feasibility study within the AS:Sk project, and relevant school-based intervention literature. The components also aligned with elements of the socio-ecological model (McLeroy et al., 1988), the YPAPM (Welk, 1999), and the TEO (Beets et al., 2016). Table 6.2 describes how each component of the intervention mapped onto these conceptual models. The control schools received all of the resources to implement the PA components following the conclusion of the intervention. The ClinicalTrials.gov ID registration number of this clustered RCT was NCT03283904.

Table 6.1. Detail of each component.

	Intervention Component	Content Description	Study 2 Findings	Associated/Supportive Research	Duration	Frequency
1	Active Breaks	Twenty-three activity cards were created with pictures on the front demonstrating the activity and instructions on the back for the teacher to read out (printed and laminated onto A3 paper). All activities were designed for use within the restricted space of a classroom. Each activity card was designed to last for 30 seconds. <i>(Delivery: class teacher)</i>	Deemed feasible and acceptable. No changes needed.	Pilot primary school AB study with a similar 5-minute implementation protocol (Watson, Timperio, Brown, & Hesketh, 2017). ABs reported to improve PA during school (Carlson et al., 2015).	5 minutes	x1/day
2	Bounce at the bell	Teachers were provided with a suggested jump routine (star jumps, tuck jumps) and instructed to perform this whenever the bell sounded in class (usually for morning break, lunch break and the end of the school day). The jumps were to be performed once the lesson had finished just before leaving the classroom. <i>(Delivery: class teacher)</i>	N/A	Used in a PA school-based intervention for increasing bone strength (no PA outcomes). Reported as a simple classroom-based exercise without the need for equipment or access to a gym, requiring only 3 minutes of the school day (Macdonald, Kontulainen, Khan, & McKay, 2007).	1-2 minutes	x3/day
3	BTM videos	Videos provided by Les Mills (http://www.lesmills.com/borntomove), included instructor led high intensity motor skills set to contemporary music, designed to improve health-related and skill-related fitness. Videos required hall/gym space with a projector screen connected to an internet enabled device. It was suggested that the videos could be used as an active assembly as the hall/gym would be free at that time. <i>(Delivery: class teacher)</i>	Frequency reduced due to hall/gym accessibility barrier.	Evaluation of BTM pilot programme concluded that live 30-minute BTM lessons delivered by a trained instructor engaged children in significantly more MPA than during regular PE (Fairclough et al., 2016).	10 minutes	x2/week
4	Daily Mile or 100 Mile Club	Schools planned an outdoor route around the school grounds. If the route was smaller than a mile schools tracked how many laps were required to achieve the mile. For the 100 mile club, each child received a recording sheet to record the distance ran and to count how many miles they had accumulated. For the daily mile option, no tracking of distance ran was required. <i>(Delivery: class teacher)</i>	N/A	Short-term follow up results of a study implementing 100 MC in lower-income schoolchildren indicated significant positive effect on ST (Sacheck et al., 2017). The DM is cited by the UK government as an option for schools to deliver PA and findings show it is effective at increasing MVPA (Chesham et al., 2018; HM Government, 2016).	15 minutes	x1 day (DM) x3/week (100 MC)

	Intervention Component	Content Description	Study 2 Findings	Associated/Supportive Research	Duration	Frequency
5	Playground activity challenge cards	There were 5 games in total which all included 5 different activity cards. Activities were easy to perform exercises designed for children to follow independently without the need for any equipment (apart from a ball in one of the games) or the need for teachers to set up or assist with games. They were placed around the playground in places visible for the children, for example tied to benches or gates, and the inside of classroom windows. <i>(Delivery: child independent/playground staff)</i>	Challenges/games designed for children to follow independently due to teacher barriers cited.		5 minutes per game	Every playground break
6	PE teacher training	The school sport coach or member of staff who was due to deliver the PE lessons in each intervention school during the 8-week intervention period were sent access to an online training session (immediately after intervention allocation, the week prior to the intervention period). The focus of the online content was how to increase high intensity PA and reduce time spent stood still during PE, for example with more active warm ups/cool downs. Access to follow-up support via email was provided. <i>(Delivery: PE teacher)</i>	N/A	Supportive, Active (high levels of PA, minimal transition time), Autonomous (opportunity for student choice), Fair, Enjoyable (SAAFE) framework used to guide staff for the planning and delivery of their PE lessons (Lubans et al., 2017). LET US Play principles also highlighted to staff (Brazendale et al., 2015). Including removing lines, eliminating elimination, reducing team sizes and rethinking space, equipment and rules.	N/A	Every PE lesson
7	Newsletters	Short paragraphs of information relating to PA and its importance for health and wellbeing were sent to schools. Schools were asked to insert each message into their school newsletter which is sent home to all parents (most commonly online via an email or through the school website).	N/A	Use in previous school-based PA interventions as a means for engaging parents (Lubans et al., 2012; Sutherland et al., 2016; Vander Ploeg, Maximova, McGavock, Davis, & Veugelers, 2014)	N/A	Weekly/every 2 weeks (school dependent)
8	Activity homework	Children received a PA homework pack which included a letter to parents and 10 different challenges. A separate pack of the individual challenges on small pieces of paper were also provided for children to take home if their original pack had been lost at home. Children received a weekly diary to complete whenever they had done PA at home. A blank class chart was provided to be populated with names and updated every week with school rewards such as house points for those who completed the most PA at home.	N/A	Use in previous school-based PA interventions (Fairlcough et al., 2013; Kriemler et al., 2011)	N/A	Encouraged to be 1/day

Table 6.2. Intervention component mapping to theory.

Intervention Component	Socio-ecological model level	YPAPM elements	TEO
1 Active Breaks	Interpersonal (peers and teachers) Organisational (school environment) Public policy (30 mins MVPA/school day)	Reinforcing (peers and teachers) Predisposing/Reinforcing (enjoyment cited in Study 2)	Expansion (replacement of ST class time for classroom-based activities)
2 Bounce at the bell	Interpersonal (peers and teachers) Organisational (school environment) Public policy (30 mins MVPA/school day)	Reinforcing (peers and teachers)	Expansion (replacement of ST class time for classroom-based activities)
3 BTM videos	Interpersonal (peers and teachers) Organisational (school environment) Public policy (30 mins MVPA/school day)	Reinforcing (peers and teachers) Predisposing/Reinforcing (enjoyment cited in Study 2)	Expansion (replacement of ST class time for hall/gym-based activities)
4 Daily Mile/100 Mile Club	Interpersonal (peers and teachers) Organisational (school environment) Public policy (30 mins MVPA/school day)	Reinforcing (peers and teachers)	Expansion (replacement of ST class time for outdoor activity)
5 Playground activity challenge cards	Interpersonal (peers and teachers) Organisational (school environment) Public policy (30 mins MVPA/school day)	Reinforcing (peers and teachers)	Enhancement (of playground environment to make it conducive to PA)
6 PE teacher training	Interpersonal (teachers) Organisational (school environment) Community (EHU training) Public policy (30 mins MVPA/school day)	Reinforcing (teachers)	Enhancement (replacement and reduction of ST for PA during PE lessons)
7 Newsletters	Interpersonal (family) Organisational (school newsletters) Public policy (60 mins MVPA/ day)	Reinforcing (family) Predisposing/Reinforcing (beliefs/attitudes)	
8 Activity homework	Interpersonal (family) Public policy (60 mins MVPA/ day)	Reinforcing (family)	Enhancement (reducing home-based ST and increasing PA)

6.3.4 Measures

The primary outcome for this study was school day MVPA. The secondary outcomes were achieving 30 minutes MVPA/school day, school day ST, whole weekday ST and PA levels, CRF, and body size (BMI z-score). Measurement protocols at baseline and follow up were the same at both time points and took place within the school grounds. Baseline measures were taken in September 2017, with follow up measures taken in November and December 2017. Follow up measures in control schools were taken 10-11 weeks after baseline. Follow up measures in intervention schools were taken in the week immediately after the eight-week intervention period (11 weeks after baseline).

Figure 6.2 outlines the study timeline.

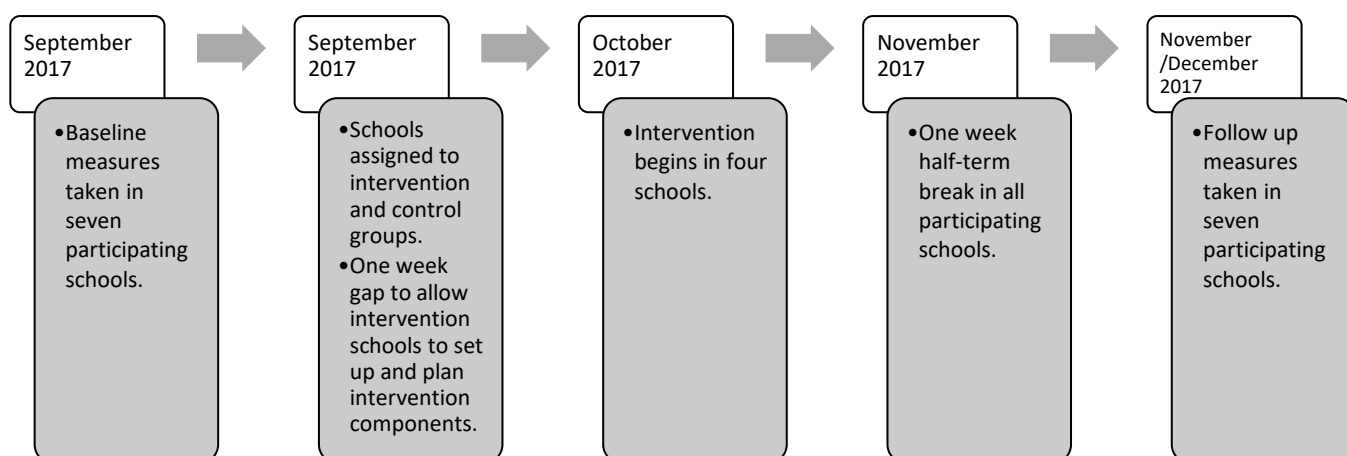


Figure 6.2. The AS:Sk multi-component intervention timeline.

The measures collected are listed below. Unless stated, procedures for each measure are that which are outlined in Chapter 3.

- *Objective Physical Activity*

Children wore an ActiGraph GT9X triaxial accelerometer (ActiGraph, Pensacola, FL, USA) which were each initialised to record raw accelerations at a frequency of 100 Hz. Minimum wear time to be included in the analysis was

set to 10 hours for a minimum of three weekdays at both baseline and follow up (Rich et al., 2013). The time periods explored in the analyses included the school day (defined by schools as the time which the timetable begins and the time children are dismissed) and also whole week day (defined as 7 am to 10 pm). Published ENMO prediction equations were used to identify cut-points for classifying activity as MVPA (child-specific 3 METs) (Hildebrand et al., 2014). As there is no consensus as to the most appropriate ENMO ST cut-points (Hildebrand et al., 2017), we also applied the Hildebrand et al. (2014) regression equations using 1.5 METs, which resulted in values of 50 mg. The ENMO cut-points used are displayed in Table 6.3.

Table 6.3 ENMO cut-points used.

	Sedentary Time	Light PA	Moderate PA	Vigorous PA
ActiGraph (mg)	0-49	50-200	201-706	707-8000

- *Anthropometrics.*
- *BMI z-score.*
- *CRF.*
- *Psychological Constructs.*
- *Area-level deprivation.*

6.4 Analyses

Preliminary analyses (values of skew and kurtosis, Kolmogorov-Smirnov test) revealed that the distribution of the ST and PA outcome variables did not all meet the assumptions of normality. Square root transformations, reciprocal and log

transformations normalised some but not all of the data. Therefore, on the basis that regression analyses are robust to violations of normality, it was decided to proceed with untransformed data (Vincent & Weir, 2012). Descriptive statistics (mean and standard deviations) were calculated out for the outcomes of all participants at baseline and follow-up. Multilevel modelling was performed using MLwiN Version 2.36 (Rabesh et al., 2009) to determine the effects of the intervention. Multilevel analysis is an extension of 'standard' regression techniques (Twisk, 2006) and is a common method within intervention literature (Fairclough et al., 2013). Multilevel modelling was appropriate for use in this study given the clustered structure of children within the seven participating schools. Therefore, a 2-level data structure was used with children defined as the first level of analysis, and schools as the second level of analysis.

Continuous outcome variables were school day ST, LPA and MVPA, whole weekday ST, LPA and MVPA, CRF and BMI z-score. The dichotomous outcome variable studied (thus logistic multilevel analysis) was achieving 30 minutes MVPA/school day. Regression coefficients for the group variables ('0' indicating control schools and '1' indicating intervention schools) reflected between-group differences in the outcome measures (adjusted for baseline values and covariates). Initially, 'crude' interaction analyses were conducted with only the grouping variables and the outcome variable at baseline included in the model (Twisk, 2006). Potential confounding covariates were then added to 'adjusted' models whilst still controlling for baseline outcome variables. These potential confounding covariates were selected based on previous research which has deemed them to be influential to the outcomes.

Gender was added to all of the models. Research indicates gender differences are evident in all the outcome variables (Cooper et al., 2015; Zaqout et al., 2016). Controlling for gender also means that maturation which differs between girls and boys, and has been reported to influence PA is accounted for (Bacil et al., 2015). IMD rank was added to the models with PA and ST outcomes. There is evidence of deprivation impacting the amount of self-reported MVPA and school specific segments such as recess (Baquet et al., 2014; Borraccino et al., 2009). Lower SES has been linked to higher screen time, but also lower overall ST (Coombs et al., 2013; Pulsford et al., 2013). Increased adiposity is associated with a reduction in PA and poorer CRF, and was therefore included in these outcome models (Richmond et al., 2014; Santos et al., 2014). Number of shuttles completed, as an indicator of CRF, was added to PA, MVPA and BMI z-score outcome models. Compliance of the PA guidelines is associated with higher fitness, and lower fitness is associated with higher fatness (Grund et al., 2000; Silva et al., 2013). The final additions to PA outcome models were self-efficacy and enjoyment scores, due to their inclusion in the YPAPM as predisposing factors for PA participation (Welk, 1999). Levels of participation in ST and MVPA are associated with CRF and BMI z-score, whole weekday values were therefore added to these models (Mann et al., 2017; Santos et al., 2014; Wilkie et al., 2018). Accelerometer wear time was also added to models with whole weekday outcomes. Regression coefficients from the models were assessed for significance using the Wald statistic and the following equation (Regression Coefficient/Standard Error)². Statistical significance was set at $p < 0.05$.

The evaluation of potential effect modification was also carried out on several dichotomous covariates (gender, weight status, central obesity risk, and fitness status). These analyses determined whether the intervention effects were different for the subgroups. Interaction terms were added to the models, consisting of a multiplication of the main determinant (intervention) and the potential effect modifier (Twisk, 2006). Due to the reduced power which interaction terms have, statistical significance for this analysis was set at $p < 0.1$ (Twisk, 2006).

6.5 Results

6.5.1 Preliminary Results

Descriptive statistics are displayed in Table 6.4 for all participants and by gender, for baseline and follow-up measures.

Table 6.4. Descriptive characteristics of participating children (control and intervention, baseline and follow up; Mean (SD) where applicable).

Measure	Sex	Baseline				Follow Up			
		<i>n</i>	Control	<i>n</i>	Intervention	<i>n</i>	Control	<i>n</i>	Intervention
Stature (cm)	Boy	54	137.5 (7.2)	60	136.9 (5.1)	52	138.6 (7.2)	56	137.7 (4.9)
	Girl	60	136.7 (6.7)	58	137.8 (6.0)	58	137.5 (6.5)	54	139.0 (6.2)
	All	114	137.1(6.9)	118	137.3 (5.5)	110	138.0 (6.8)	110	138.3 (5.6)
Body mass (kg)	Boy	54	34.9 (8.8)	59	33.7 (6.3)	52	35.9 (8.8)	55	34.0 (6.3)
	Girl	60	35.2 (8.5)	58	37.1 (8.1)	56	35.7 (9.1)	54	38.0 (8.5)
	All	114	35.1 (8.6)	117	35.4 (7.4)	108	35.8 (8.9)	109	36.0 (7.7)
BMI (kg·m ²)	Boy	54	18.3 (3.2)	59	17.9 (2.6)	52	18.5 (3.2)	55	17.8 (2.6)
	Girl	60	18.7 (3.5)	58	19.5 (3.6)	56	18.7 (3.7)	54	19.6 (3.6)
	All	114	18.5 (3.3)	117	18.6 (3.2)	108	18.6 (3.5)	109	18.7 (3.3)
BMI z-score	Boy	53	0.7 (1.2)	56	0.5 (1.1)	51	0.7 (1.1)	53	0.5 (1.0)
	Girl	60	0.7 (1.3)	57	0.9 (1.2)	56	0.5 (1.2)	53	0.9 (1.2)
	All	113	0.7 (1.2)	113	0.7 (1.2)	107	0.6 (1.2)	106	0.7 (1.2)
Overweight/Obese (%)	Boy	53	22.6	56	21.4	51	25.5	53	18.9
	Girl	60	35.0	57	43.9	56	35.7	53	47.1
	All	113	29.2	113	32.7	107	30.8	106	33.0
Waist circumference (cm)	Boy	54	63.7 (9.5)	59	63.5 (7.8)	52	66.7 (9.1)	55	63.8 (6.7)
	Girl	60	63.7 (9.4)	58	65.9 (8.8)	56	65.1 (10.1)	54	66.1 (8.5)
	All	114	63.7 (9.4)	117	64.7 (8.3)	108	65.9 (9.6)	109	64.9 (7.7)
Maturity offset (y)	Boy	51	-3.2 (0.3)	57	-3.3 (0.2)	51	-3.0 (0.4)	54	-3.0 (0.3)
	Girl	60	-2.2 (0.4)	57	-2.1 (0.3)	57	-1.8 (0.5)	53	-1.8 (0.5)
	All	111	-2.7 (0.7)	114	-2.7 (0.6)	108	-2.3 (0.7)	107	-2.4 (0.7)
CRF (Number of shuttles)	Boy	52	36.7 (18.3)	59	33.1 (15.2)	50	34.1 (18.9)	57	36.2 (17.6)
	Girl	58	28.2 (13.3)	55	25.1 (11.4)	57	25.3 (12.5)	54	25.2 (11.6)
	All	110	32.3 (16.3)	114	29.2 (14.0)	107	29.4 (16.3)	111	30.9 (15.9)
IMD Rank	Boy	51	5618.8 (5324.0)	59	6379.4 (7995.8)	N/A		N/A	
	Girl	58	5811.1 (6396.3)	56	8322.6 (8497.7)	N/A		N/A	
	All	109	5721.1 (5892.7)	115	7325.7 (8265.5)	N/A		N/A	

6.5.2 Intervention Effects

Table 6.5 shows the intervention effects on each outcome. In the adjusted models, time spent engaged in ST during the school day was significantly lower for the intervention children compared to the control group (-9.0 min; $p = 0.01$). There were no intervention effects on any of the remaining outcome measures, although the trends for school day PA and CRF were in a favourable direction. The odds of achieving 30 min of MVPA per school day was 2.79 times higher in the intervention group compared to the control group, however this did not reach significance ($p = 0.07$).

6.5.3 Sub-Group Analyses

Table 6.6 shows the results of the sub-group interaction effects. There were no post-intervention interaction effects in any of the dichotomous variables (sex, weight status, central obesity risk, fitness status) on the outcomes of school day ST and PA, whole day ST and PA, BMI z-score, and CRF.

Table 6.5. Multilevel model analyses of the outcome measures.

Outcome measure	Crude model ^a			Adjusted model ^b		
	β or OR	95% CI	<i>p</i>	β or OR	95% CI	<i>p</i>
School day ST	10.1^c	-17.8 to -2.4	0.01	-9.0^c	-17.7 to -0.2	0.04
School day LPA	4.2 ^c	-1.1 to 9.4	0.1	3.5 ^c	-1.9 to 8.9	0.2
School day total PA	7.1 ^c	-1.1 to 15.2	0.1	5.4 ^c	-2.0 to 12.8	0.2
School day MVPA	1.9 ^c	1.8 to 2.1	0.5	1.5 ^c	-4.0 to 7.0	0.6
30 minutes MVPA/school day	2.73^d	0.36 to 2.20	0.03	2.79 ^d	0.49 to 2.71	0.07
Whole day ST	-0.2 ^c	-23.4 to 22.9	1.0	-2.7 ^c	-25.1 to 19.7	0.8
Whole weekday LPA	-2.7 ^c	-14.2 to 8.8	0.9	-8.8 ^c	-20.3 to 2.7	0.1
Whole weekday total PA	-2.5 ^c	-19.7 to 14.7	0.8	-12.3 ^c	-30.2 to 5.7	0.2
Whole weekday MVPA	-0.9 ^c	-10.5 to 8.7	0.7	-4.1 ^c	-13.9 to 5.7	0.4
CRF	4.9^c	0.8 to 8.9	0.02	3.7 ^c	-0.1 to 7.6	0.06
BMI z-score	0.0 ^c	-0.2 to 0.2	0.8	0.0 ^c	-0.2 to 0.2	1.0

CI confidence interval. Values reflect the intervention effects (i.e., between group differences) between baseline and post intervention. Values in bold denote beta (95% CI) and significance values of outcomes with significant intervention effects ($p < 0.05$).

^a Adjusted for group and baseline value of the outcome measure. ^b Additionally adjusted for confounding covariates. ^c β value. ^d Odds ratio.

Table 6.6. Follow up intervention sub-group interactions.

Outcome measure			Interactions			
			Intervention *sex	Intervention * weight status	Intervention * central obesity risk	Intervention * fitness status
School Day Activity	ST	β	5.3	-4.2	-2.9	4.2
		95% CI	-9.1 to 19.6	-20.1 to 11.8	-19.2 to 13.4	-11.0 to 19.5
		<i>p</i>	0.5	0.6	0.7	0.6
	LPA	β	-8.5	8.0	0.7	-6.4
		95% CI	-18.8 to 1.8	-2.7 to 18.6	-10.3 to 11.7	-16.9 to 4.0
		<i>p</i>	0.1	1.0	0.9	0.2
	Total PA	β	-9.2	7.7	1.1	-6.0
		95% CI	-22.9 to 4.3	-7.2 to 22.5	-14.0 to 16.2	-20.3 to 8.2
		<i>p</i>	0.2	0.3	0.9	0.4
	MVPA	β	-0.3	-1.2	-1.0	0.4
		95% CI	-6.4 to 5.8	-8.0 to 5.7	-8.0 to 5.9	-6.1 to 7.0
		<i>p</i>	0.9	0.7	0.8	0.9
	ST	β	-24.5	3.6	19.2	-6.3
		95% CI	-71.3 to 22.2	-45.7 to 52.9	-31.0 to 69.4	-53.9 to 41.3
		<i>p</i>	0.3	0.9	0.5	0.8
Whole Weekday Activity	LPA	β	-9.2	5.5	7.9	-18.3
		95% CI	-32.6 to 14.1	-18.7 to 29.7	-17.0 to 32.7	-42.0 to 5.3
		<i>p</i>	0.6	0.7	0.5	0.1
	Total PA	β	-15.4	2.6	19.6	-26.7
		95% CI	-49.6 to 18.9	-33.8 to 39.0	-17.2 to 56.5	-61.6 to 8.3
		<i>p</i>	0.4	0.9	0.3	0.1
	MVPA	β	-6.3	-3.0	11.5	-9.0
		95% CI	-21.3 to 8.7	-19.5 to 13.6	-5.2 to 28.2	-24.8 to 6.8
		<i>p</i>	0.4	0.7	0.2	0.3
	CRF	β	2.0	-0.5	0.2	2.0
		95% CI	-2.9 to 6.9	-5.7 to 4.8	-5.4 to 5.9	-3.0 to 7.0
		<i>p</i>	0.4	0.9	0.9	0.4
	BMI z-score	β	-0.2	0.1	-0.2	0.0
		95% CI	-0.4 to 0.0	-0.1 to 0.4	-0.4 to 0.1	-0.2 to 0.3
		<i>p</i>	0.1	0.3	0.3	0.8

Crude analyses (adjusted for interaction terms, group, baseline value of the outcome measure) of interaction terms to evaluate potential effect modification.

6.6 Discussion

This study aimed to: (1) assess the impact of the AS:Sk multi-component intervention on the primary outcome of school day MVPA; and (2) assess the impact of the AS:Sk multi-component intervention on the secondary outcomes of achieving 30 min MVPA/school day, school day ST, whole weekday ST and PA levels, CRF and body size. Overall, after accounting for confounding variables, the intervention had a significant effect on school day ST which was significantly less for the intervention children by 9 min per day compared to the control group. Trends were observed for favourable changes in school day LPA, PA, MVPA, achieving 30 min school day MVPA, and CRF, however these did not reach significance.

The AS:Sk intervention demonstrates school-based PA components which are novel in their ability to target various time points in the school day with no financial costs to the school. The significant effects that the intervention had on ST are consistent with previous research. For example, the Finnish Schools on the Move study, which allowed schools to plan their own interventions with strategies such as longer recess periods, increased use of equipment during the school day, and staff training, reported decreased ST at 1.5 year follow-up in children similar in age to those in AS:Sk (Haapala et al., 2017). In contrast, the Active Living multi-component school-based intervention, which used techniques to target PA in school, before, and after school with active transport, and also during leisure time observed a general increase in ST at 12 months follow-up (2.2% more daily time spent in sedentary behaviour), which the authors speculated could have been due to the participants increase in age (Van Kann et al., 2016). Given the short follow up period in the current study, it is difficult

to establish whether the initial positive impact on ST would be sustained long term, inhibiting the anticipated age-related increase. Project timescale and subsequent funding precluded the utilisation of a longer-term intervention period and follow up evaluations.

A significant intervention effect on school day ST has implications for both public health policy and child health outcomes. Public health guidelines in both the UK and other countries recommend that overall sedentary time should be limited in children and young people (Chief Medical Officer Department of Health, 2011; Health Council of the Netherlands, 2017; Tremblay, Carson, et al., 2016). Moreover, research has explored the relationship between ST and health indicators, subsequently highlighting the detrimental effects that ST can have on child health. For example, time spent being sedentary is positively associated with BMI z-score, and negatively associated with fitness in children and youth (aged 6–17 years) (Carson, Tremblay, Chaput, & Chastin, 2016).

Results indicated a modest and non-significant increase in school day MVPA of 1.5 min. Sutherland and colleagues also reported modest increases in MVPA after the implementation of their multi-component school-based programme, 'PA 4 Everyone' (Sutherland et al., 2016). Differences to control students were significant, with 3.9 more minutes of MVPA per day accumulated by intervention students (Sutherland et al., 2016). Conversely, the 'Active Living' multicomponent school-based PA intervention had no significant effect on MVPA per day and saw a general reduction in PA (Van Kann et al., 2016).

The addition of even small amounts of MVPA to the school day may be beneficial to physical health, particularly when compared to interventions which see negative outcomes and also when the age-related decline in MVPA is considered (Dumith, Gigante, Domingues, & Kohl, 2011). However, the meaningfulness of potential benefits could be questioned. The addition of MVPA does predict positive effects with decreased adiposity, whilst the replacement of MVPA with any other movement behaviour predicts negative effects with higher adiposity and lower CRF (Dumuid et al., 2018; Fairclough et al., 2017). However, these results are based on 15 min reallocations of time which is considerably more than the intervention effect on MVPA in the current study.

It is difficult to explain why the AS:Sk intervention reduced ST but did not increase MVPA. The most frequently implemented components replaced class time (ABs and BTM vides for example) which is traditionally spent sedentary, thus change in this behaviour is more likely. Conversely, there was less guarantee that intervention strategies would stimulate PA of sufficient intensity to increase MVPA, which is also dependent on factors such as motivation, space, time, and fitness. The context of each participating school which differs significantly from one to the other should also be considered when discussing the results of the intervention. It is likely that school differences beyond the control of the AS:Sk intervention such as policies, timetables, and staff for example will have influenced PA levels. Some examples could include, class sizes, the type of staff who supervise playground breaks, the type of staff who deliver PE lessons, and potentially the number of lessons per day.

Researchers and practitioners should focus on developing sustainable strategies for increasing MVPA participation during the school day given its significance for physical health. Understanding how interventions are implemented within schools from the perspective of teachers and students alike, may help in the development of successful school-based techniques. The process evaluation of interventions is advocated by the UK MRC and can play a crucial role in understanding and learning from findings (Moore, Audrey, Barker, Bond, Bonell, & Hardeman, 2015; Naylor et al., 2015). Despite this, implementation data are rarely reported in the literature and a lack of standardised definitions and measurements of implementation contributes to this (Naylor et al., 2015). A review into the barriers and facilitators to the implementation of PA policies in schools concluded that the body of literature surrounding this topic area from a theoretical perspective was scarce (Nathan et al., 2018). Implementation of PA in the classroom setting has received more coverage in the literature recently, including perspectives from teachers which has provided useful and important considerations for future interventions (Dyrstad et al., 2018; Routen et al., 2018).

There were no significant intervention effects on whole weekday movement behaviours (including out of school hours). A previous systematic review concluded that school-based interventions had no effect on leisure time PA (Dobbins, De Corby, Robeson, Husson, & Tirilis, 2009). Whilst results were not significant, intervention effects on whole weekday PA were in the negative direction. This could suggest that children compensated for the increased PA opportunities they were provided with during the school day by decreasing their leisure time PA. This theory has also been suggested by previous interventions in which increases in school day MVPA did not

translate into positive effects across the day (Haapala et al., 2017). An intervention which increased the number of compulsory PE lessons found that the percentage of time spent in MVPA during school was greater; however, the percentage of time spent in MVPA out of school was lower when both time periods were compared to normal schools (Møller et al., 2014). Further PA compensation research has also suggested that for every additional 10 min spent in MVPA, children engaged in 5 min less the following day (Ridgers, Timperio, Cerin, & Salmon, 2014). That being said, not all interventions report compensation effects, for example a review of school-based interventions found five in total which were effective at increasing overall PA (Kriemler et al., 2011). AS! BC is one of these interventions that was effective at increasing overall PA (Naylor et al., 2008). Activities implemented across six action zones in this intervention included extracurricular and family and community, these zones in particular may have been the important factor which limited PA compensation outside of the school day (Naylor et al., 2008).

The CSPAP approach to PA promotion comprises of five different components or points of intervention which includes PA before and after school (Erwin et al., 2013). Whilst attempts were made to target the out of school period with the PA homework component of the AS:Sk intervention, it would appear that more substantial efforts are needed, for example with school-based extracurricular PA opportunities, rather than PA that requires children to engage with in the home environment. Many barriers to participation in out of school PA exist, including parental reported barriers such as safety concerns (Noonan, Boddy, Fairclough, & Knowles, 2017). Screen time has also been reported by parents as a barrier, particularly as it is seen as the 'norm' for

children to engage and therefore parents struggle to limit it (Noonan, Boddy, et al., 2017; Solomon-Moore et al., 2018). Parents have reported that engagement in family-based PA intervention programmes would be the most effective way to increase their child's PA (Noonan, Boddy, et al., 2017). The out of school time period for PA participation requires more attention, even from interventions which are primarily designed as school-based, in which the out of school barriers to PA participation and the desired family-based sessions should be considered.

6.6.1 Strengths and Limitations

The AS:Sk intervention had several strengths. Firstly, it was developed through prior formative research and was theoretically underpinned by conceptual behaviour change models (Beets et al., 2016; McLeroy et al., 1988; Welk, 1999). This approach adheres to MRC guidelines for the development of complex interventions (Craig et al., 2008). In addition, school staff were provided with the flexibility to implement the PA components when it best suited their class or school. This approach is most feasible in the “real-world” school setting in which unpredictable changes to timetables can happen, thus programme flexibility has previously been reported by teachers as a facilitator to implementation (Naylor, Macdonald, Zebedee, et al., 2006). There was also no financial cost to the schools or the project. This would suggest that the intervention can be self-sustained by schools alone and, therefore, has potential for long-term implementation, although the teacher burden relating to planning and implementation should not be understated. The use of objectively measured PA to assess the intervention effect is an important strength of the study. Furthermore, the use of raw accelerations avoids the uncertainty of pre-processed data such as counts

and the possibility that signal-filtering methods alter study results (Freedson et al., 2012; Peach et al., 2014). A limitation of the study is the modest sample size, which may have resulted in a lack of power in the statistical test outcomes, particularly the positive outcomes which did not reach statistical significance. The number of children who met the accelerometer wear-time criteria at both baseline and follow up measures also impacted on the final sample size. A further limitation was the timing of the follow up measures in both control and intervention schools which may have contributed towards the intervention not having a significant effect on PA outcomes. By necessity, measures were taken at an atypical school period, in the final few weeks before Christmas. It is in this period that school timetables are often disregarded and festive activities sometimes replace usual practice. Thus, the activity of children may not be representative of the rest of the school year. Intervention schools in particular may not have implemented the intervention in these final school weeks as they may have done so earlier in the school term. Furthermore, given that intervention implementation was sustained by school staff only, without any external support, it is likely that there were differences in implementation between participating schools. Gaining an accurate and objective record of implementation frequency across the eight-week period within each participating school may require daily researcher visits during the intervention period, which was not possible due to the time constraints of the research staff. Alternatively, teacher logs could be used, but these may be more subject to bias. Quantitative data to illustrate implementation frequency across the eight-week period was, therefore, not available, and it is acknowledged that differences in implementation frequency between schools likely impacted the results, such as the lack of significant impact on PA outcomes. The lack of a more long-term

follow up measurement period was also a limitation. Given that follow up measurements were taken only eight weeks after implementation it is difficult to understand the sustainability of the intervention. A further weakness relating to the measurements was that inter-rater reliability was not examined, and the same researchers did not carry out baseline and follow up measures. This could have implications on the data, particularly waist circumference. Research has highlighted that measuring waist circumference is subject to significant inter-operator variability and could potentially lead to misclassifying participants (Panoulas, 2008). The overall short intervention implementation period of eight weeks is also a weakness of the study, as interventions of longer duration have been shown to be more effective (Kriemler et al., 2011).

6.7 Conclusions

The AS:Sk multi-component school-based PA intervention had a significant positive effect on school day ST. There were no significant intervention effects on any of the other outcome measures, including the primary outcome of school day MVPA. The small sample size of the current study was an important limitation within the study and may have contributed to the analyses lacking power. The school day period should continue to be a priority. Its importance for PA participation has previously been highlighted, and this study indicates that positive effects on ST in particular are achievable across the school day. Modifications to out-of-school components would be beneficial to avoid any compensation effects on PA participation. The AS:Sk intervention has potential to be scaled up to a full trial following modifications based on the results of this pilot study. Future research should focus on exploring ways in

which MVPA participation can be increased during the school day. This may be with the development of appropriate school-based techniques or, conversely, focusing on how to improve the implementation of established techniques (such as the components of the current intervention) through process evaluation research.

Thesis Study Map

Study	Objectives and Key Findings
Study 1: Predictors of Segmented School Day Physical Activity and Sedentary Time in Children from a Northwest England Low-Income Community	<p>Objectives</p> <ul style="list-style-type: none">• Establish the current MVPA and ST levels of children aged 9-10 years who attend schools in a low-income town of Northwest England.• Investigate the child and school-level influences on children's PA and ST during segmented school hours. <p>Key Findings</p> <ul style="list-style-type: none">• On average both boys and girls did not achieve the recommended 60 min of MVPA on average. School-based PA interventions are warranted.• Significant child-level predictors were maturity offset, CRF, weight status, WtHR, ST, and MVPA.• Significant school-level predictors were number of children on roll and playground area.
Study 2: Acceptability and feasibility of single-component primary school physical activity and sedentary behaviour interventions to inform the AS:Sk Project	<p>Objectives</p> <ul style="list-style-type: none">• Investigate the feasibility and acceptability of single-component school-based PA interventions.• Evaluate the effectiveness of single-component school-based PA interventions on levels of school-based MVPA and ST. <p>Key Findings</p> <ul style="list-style-type: none">• Implementation challenges related to space within the school environment, competing demands of teachers and other members of staff, such as timetable constraints and other responsibilities.• The AB and BTM interventions indicated positive effects on levels of MVPA and ST.

<p>Study 3: Evaluation of a Pilot School-Based Physical Activity Clustered Randomised Controlled Trial — Active Schools: Skelmersdale</p>	<p>Objectives</p> <ul style="list-style-type: none"> • Evaluate the effectiveness of the AS:Sk multi-component intervention on levels of school-based MVPA and ST. <p>Key Findings</p> <ul style="list-style-type: none"> • The AS:Sk multi-component intervention had a significant effect on school day ST (significantly less for intervention children by 9 min per day compared to control group). • There were no intervention effects for PA outcomes.
<p>Study 4: The process evaluation of Active Schools: Skelmersdale: a pilot school-based physical activity clustered randomised controlled trial</p>	<p>Objectives</p> <ul style="list-style-type: none"> • Explore how the AS:Sk multi-component intervention was implemented in participating schools. • Investigate the feasibility and acceptability of the AS:Sk multi-component school-based PA intervention.

**Chapter 7 (Study 4): The process evaluation of
Active Schools: Skelmersdale: a pilot school-
based physical activity clustered randomised
controlled trial.**

This study is currently under peer-review in BMC Public Health.

Taylor, S. L., Noonan, R. J., Knowles, Z. R., Owen, M. B., McGrane, B., Curry, W. B., & Fairclough, S. J. (*In Review*). Process evaluation of a pilot multi-component physical activity intervention - Active Schools: Skelmersdale. BMC Public Health.

7.1 Author Contribution

S.T. carried out preparations for data collection, including the design of interview guides with assistance from R.N. and M.O. S.T. carried out all focus groups and interviews. Qualitative data was transcribed by a paid external source. S.T. conducted the full analyses of the data with assistance from Z.K. and R.N. S.T. wrote the manuscript. R.N., Z.K., M.O., B.M., W.C., and S.F. provided comments on the manuscript and read and approved the final version of the manuscript.

7.2 Introduction

Chapter 6 (Study 3) provided quantitative data to assess the impact of the AS:Sk multi-component intervention on outcomes relating to MVPA, ST and health outcomes. The current study provides qualitative data to assess the implementation of the AS:Sk multi-component intervention within participating schools. It is important to understand how the AS:Sk intervention was implemented in practice so that it can be further developed for future implementation.

This assessment of implementation is essential to understand whether an intervention is internally and externally valid (Durlak & DuPre, 2008). An accurate interpretation of either positive (e.g., increases in PA) or negative (e.g., no change or decreases in PA) outcomes is dependent on having an understanding of which aspects of an

intervention were delivered and how (Durlak & DuPre, 2008). The process evaluation of interventions is advocated by the UK MRC, which deems it to be an essential part of designing and testing complex interventions (Moore, Audrey, Barker, Bond, Bonell, & Hardeman, 2015). However, a review of the literature surrounding the implementation of school-based PA interventions conducted in 2015, concluded by stating that the literature base was lacking in both quantity and quality (Naylor et al., 2015).

MRC guidelines suggest that both quantitative and qualitative methods have an important role in process evaluations, both independently and in combination (Moore, Audrey, Barker, Bond, Bonell, & Hardeman, 2015). Commonly used qualitative methods in process evaluations include: group interviews or focus groups, one-to-one interviews, and observations/detailed field notes (Moore, Audrey, Barker, Bond, Bonell, & Hardeman, 2015). These are also common methods more specifically in the evaluation of school-based PA interventions, utilising both children and teacher views (Beltran-Carrillo, Ferriz, Brown, & Gonzalez-Cutre, 2017; Burges Watson, Adams, Azevedo, & Houghton, 2016; Martin & Murtagh, 2017c).

The primary aim of this study was to gain an understanding of how each participating school implemented the AS:Sk intervention. This included the frequency with which intervention components were implemented and also how they were incorporated into the working school day. Secondary aims included gaining perspectives from teachers and children to gain an understanding of the feasibility and acceptability of the intervention as a whole and also each separate intervention component.

7.3 Study-specific methods

All four participating intervention schools were informed of the process evaluation requirements of the study before intervention implementation. Arrangements were made with relevant staff within each school for the following procedures to be completed during and after the implementation phase of the intervention.

The previous chapter described intervention components and who they would be delivered by. Although there were differences across the components in terms of delivery, most commonly it was class teachers who were delivering intervention components to the children (e.g., ABs, bounce at the bell, BTM videos, DM/100 MC). In three of the participating schools one class teacher was responsible for intervention delivery. In one participating school, two teachers shared intervention delivery from week five of the intervention onwards, with one of the two teachers completing a phased return to work. Consequently, the second teacher was not present during the initial project meetings to discuss intervention components and a relationship was not built between the researcher and this teacher. Furthermore, communication was limited between both teachers and the researcher during the intervention period and as a result observations and teacher interviews were not completed. Child data were collected and indicated that the intervention was implemented to a certain degree, for example children were able to talk about their experiences with a number of the intervention components. Ultimately, a decision was made to exclude this school from the current study due to the missing data sources which meant that a representative report on how and when intervention components were delivered could not be acquired.

7.3.1 Procedures

7.3.1.1 Observations

The researcher conducted observations and field notes for each intervention component. Observations were conducted at an agreed time with the class teacher. Where appropriate, for example with PE lesson observations, checklists were created based on the frameworks and principles with which the teacher training resources were based upon (Brazendale et al., 2015; Lubans et al., 2017). For example, whether stationary lines queueing for activities were reduced/removed (Brazendale et al., 2015). A total of 18 observations were conducted throughout the intervention. The durations of these observations were sufficient to cover the whole period of time in which an intervention component was delivered. For example, with an AB an observation would last for 5-10 minutes, however for a PE lesson an observation could last for up to 60 minutes. During all observations, field notes were collected in relation to aspects including the number of children involved, the location within the school, the behaviour and responses of children, and the actions of teachers.

7.3.1.2 Write, draw, show and tell groups

The write, draw, show and tell (WDST) method was used with participating children to elicit their perceptions and experiences of the intervention components (Noonan, Boddy, Fairclough, & Knowles, 2016). WDST and similar draw and write techniques have been used in previous child research to explore understanding of health and, more specifically, PA perceptions and experiences (McWhirter, 2014; Noonan et al., 2016; Noonan, Fairclough, Knowles, & Boddy, 2017). The WDST process has been described fully elsewhere (Noonan et al., 2017; Noonan et al., 2016). Its philosophical

background is centred on a humanistic and 'holistic' approach in which the intervention implemented can be viewed through the eyes of the children rather than the eyes of the teacher or researcher (Noonan et al., 2016). This holistic approach is consistent with the more traditional focus group method. Focus groups have previously been used to explore children's perceptions towards PA (Hyndman, 2016; Loman, 2008; Stanley, Boshoff, & Dollman, 2013) and have been deemed an appropriate and effective mechanism for collecting information with substantial depth and breadth (Porcellato, Dughill, & Springett, 2002). However, some school-aged children in particular may struggle to find the right words to convey their thoughts and/or feelings (Gibson, 2012), and responses given can be brief and simplistic (Porcellato et al., 2002). Hence, the use of a singular approach to explore children's perceptions and lived experiences can limit understanding. Alternative approaches, such as drawings are familiar classroom-based activities that provide children with greater control over their expression compared to verbal communication (Gabhainn & Kelleher, 2002). The combination of these approaches (focus groups and drawings) through the WDST method can elicit a more comprehensive and extensive account of child perceptions and experiences.

A sub-sample of children from each school were included for the WDST method. No inclusion/exclusion criteria were set for children to be included, other than having consent to participate and that both girls and boys were selected, with the aim of an equal gender split. Once groups were arranged, they were conducted in a quiet area of the school environment where the researcher and participants could be overlooked but not overheard. Semi-structured WDST guides were developed and used to ensure

consistency across WDST groups. Questions were informed by the YPAPM (Welk, 1999) and aligned to the overarching aim of the study which was to elicit children's perceptions and lived experiences of the PA intervention components. The WDST guide was discussed with a member of the research team who developed the WDST method and has experience of qualitative research with children (Noonan et al., 2017; Noonan et al., 2016). These discussions ensured that the questions and tasks were child appropriate and would enable the study aims to be achieved. Example questions used are displayed in Table 7.1, with an indication of their alignment to the YPAPM. The use of a semi-structured interview guide and following the WDST methodology framework outlined by Noonan and colleagues (2016, 2017) ensures each WDST group which is conducted is consistent and each follows a standardised protocol. Clearly outlining the methodological decisions made and the activities conducted within the WDST process provides transparency and enhances trustworthiness, enabling future studies to adopt a similar methodological approach (Carcary, 2009).

Table 7.1. Example WDST questions.

YPAPM Factor	Intervention Component	Questions and Prompts
Predisposing – “Am I able” – <i>Perceived competence/self-efficacy.</i>	Active Breaks	<p>Were the classroom-based exercises hard or easy to complete?</p> <ul style="list-style-type: none"> - What was it about the exercises which made them easy/hard? <p>Do you feel different doing the classroom-based activities now compared to when you first started them?</p> <ul style="list-style-type: none"> - Can you think of how your body feels different?
Predisposing – “Is it worth it” – <i>Enjoyment.</i>	Born To Move videos	<p>Was it enjoyable to take part in the videos?</p> <ul style="list-style-type: none"> - What did you enjoy about the videos? - Was there anything you didn’t like about them?
Reinforcing – <i>Teacher Influence</i>	Daily Mile/100 Mile Club	<p>What did your teacher do during the mile run?</p> <ul style="list-style-type: none"> - What is like to run the mile with your teacher taking part?

The WDST process began with the researcher presenting visual illustrations of each intervention component to children. For example, an AB activity card which they would recognise from teachers holding up to the class. This opening task was not to initiate any form of conversation but rather to allow children time to reflect upon the intervention components. It also ensured that the children understood what the overarching topic of conversation was, so once questions were directed to specific intervention components children clearly understood what was being referred to. After children were shown the intervention component illustrations they were provided with a self-adhesive note-paper and were invited to write down which of the intervention components was their favourite, or they had found most enjoyable. This simple task incorporates the write and show aspects of WDST. Children were provided with the time to think about each intervention component, and then the opportunity to write down their favourite. Children then spoke aloud as they were asked to tell the group what they had written down as their favourite intervention component and explain why it was. This initial simple task helped build rapport between researcher and children and established an environment whereby sharing and listening was valued (Noonan et al., 2016). Once each child had contributed to the discussion, the session progressed with more challenging open-ended questions directed at the whole group, taken from the semi-structured WDST guide.

To conclude the session, the draw aspect of WDST was used. Children were asked to independently draw a picture of themselves completing their favourite intervention component and to consider where they were in the school environment when doing so, who they were with and how they felt whilst taking part. They were also asked to

summarise the picture with a short paragraph of words (write aspect) which would articulate the meaning embedded within their drawing. With the exception of providing children with motivational comments to continue/complete as appropriate, the researcher refrained from providing any evaluation of the children's drawings (Noonan et al., 2016). Children were provided with the opportunity to again show and explain to the drawing to the group.

Three WDST groups were conducted in total (one per school), including 16 participating children (7 boys). Group sizes comprised four and six children, and the WDST sessions lasted 20-28 (mean = 24.7) minutes. All WDST groups were recorded using a digital recorder and were transcribed verbatim for further analysis and anonymised. This resulted in 61 pages of raw transcription data, Arial font, size 12, double spaced.

7.3.1.3 Teacher Interview

Three class teachers were interviewed face-to-face by the researcher. Semi-structured interview guides were developed and used to explore teachers' perceptions and experiences of each intervention component with a view to understanding how they were implemented, the potential facilitators and barriers to implementation, and recommendations for future practice. Example interview questions included, "When have you been implementing active classroom breaks?"; "Do you think the activities are suitable for use in your classroom?"; "Are children motivated to participate in the daily mile?"; "What are the main barriers which have prevented you from using this component with your class?"; "What would your recommendations be to another teacher if they were planning on implementing similar PA strategies with their class?".

The interviews took place in a quiet, private area of the school at a convenient time for the teachers and lasted 15-28 (mean = 23) minutes. Teacher interview data consisted of 65 transcript pages raw transcription data, Arial font, size 12, double spaced.

7.4 Analyses

The study generated five separate data sources including child frequency counts of most enjoyable intervention components, child drawings, child verbatim data, teacher verbatim data, and researcher observations/field notes. For child drawings to be included, people, events, and/or places had to be recognisable. A 'mark' within a child's drawing referred to an item which could be identifiable as a theme, the most basic example being other people drawn with the child indicating peers (Knowles, Parnell, Stratton, & Ridgers, 2013; Noonan et al., 2016). Children's narratives were transcribed verbatim, classified as a written 'report', and subsequently appended to each individual drawing.

Child and teacher verbatim data, child drawings, and researcher observations/field notes were analysed through thematic analysis both inductively and deductively after the researcher was familiar with the data (reading and re-reading of transcription text) (Braun & Clarke, 2006). Transcriptions were checked against the audio recordings for accuracy, this was particularly important for this study as transcriptions were completed by a paid external source. As the YPAPM model (Welk, 1999) was used to underpin questions within the child WDST guides, this was also used for the deductive analysis of the child verbatim data, also known as theoretical thematic analysis (Braun & Clarke, 2013). This type of analysis uses an existing theory, in this case the YPAPM

model, as a guide or a thematic framework in more of a 'top-down' approach to explore particular theoretical ideas (Braun & Clarke, 2013). During the second stage of analysis initial codes from the data were produced. Codes were words or brief statements which were created to explain why a particular section of data was of interest. The researcher observation/field notes were also coded in the same way in which transcription data was analysed. For the inductive approach, a 'bottom-up' approach was used on the basis of what was in the data. For the child data in which deductive approach was also adopted, factors of influence within the YPAPM were created as pre-existing coding frame, for example, reinforcing – family, teachers, peers; predisposing – enjoyment, attitudes, beliefs, competence, self-efficacy; enabling – fitness, skills (Welk, 1999). After coding, in the next stage of analysis potential themes were created by collating coded data extracts and considering how they could be combined. At this stage, the data sources (teacher transcriptions, child transcriptions, child drawings, observations) were pooled to produce the themes presented in the results section. This approach was taken for complementary purposes, meaning that each separate data source could expand, enhance, and clarify the others (Noonan et al., 2016). Therefore, commonalities of codes across data sources were examined. For example, peer and teacher influence were pre-existing codes from the deductive analysis of child verbatim data, and these codes were also consistent with teacher and observation data. Once codes were combined, during the next stage of defining and refining themes it was important to determine what each theme captured. This study aimed to explore implementation techniques thus informing the implementation of future school-based interventions. Specific sub-themes were deemed important for providing this detail. Some codes were combined

to become sub-themes, whereas other codes alone became a sub-theme. For example, peer influence and teacher influence were coded in the earlier stages of analyses and these became sub-themes. Whereas, codes such as 'different times each day', 'changes to suit class', 'teacher adaptation to suit the children', 'adaptations for engagement', all became a sub-theme of 'Flexibility and adaptability'.

This triangulation of methods generating five separate data sources allows for cross-data validity checks between the child, teacher, and researcher (Patton, 1999). Further triangulation took the form of a presentation of the verbatim quotations and child drawings to two members of the supervisory team who cross-examined against the themes in reverse to ensure accuracy and provide alternative perspectives. This process continued until an acceptable consensus had been reached by the group (Ridgers, Knowles, & Sayers, 2012). Methodological and investigator triangulation combined with the use of verbatim transcription of data ensures methodological rigour, credibility and transferability (Carter, Bryant-Lukosius, DiCenso, Blythe, & Neville, 2014; Mackintosh et al., 2011). Where verbatim direct quotes are used, the data source, school, and gender of participants are outlined for clarification.

7.5 Results

There were four themes generated from all data sources: implementation methods, child engagement, facilitators, and barriers. These four themes were then broken down further into more specific sub-themes. Themes are displayed in Table 7.2.

Table 7.2. Emerging themes from the data sources.

Themes	Sub-theme
Implementation Methods	How
	When
Child engagement	Enjoyment
	Positive behaviour
Facilitators	Peer Influence
	Teacher Influence
	Staggered implementation
	Incentives, rewards, challenges and competition
	Flexibility and adaptability
	Child ownership
	Routine
Barriers	Time within an intense curriculum
	Space
	Sustaining child interest
	Parental support
	School policies

7.5.1 Implementation Methods

A summary of implementation methods across the three schools is displayed in Table 7.3. Schools were given freedom to implement the intervention components when it best suited their class and timetable. It was therefore important to summarise the differences between schools and understand how schools made the intervention components part of their working school day. Implementation methods differed across each school with limited similarities observed between them. Schools also made adaptations to component protocols to suit their own needs.

Table 7.3. Summary of implementation methods; how and when the participating intervention schools implemented intervention components.

	School 1	School 2	School 3
Active classroom breaks	Used within longer morning or afternoon sessions to transition between tasks or break up tasks.	Implemented either at the beginning or end of a morning lesson, usually a maths or English lesson. Sometimes implemented immediately after returning to class from a morning assembly (which included 20-30 minutes of sitting, twice a week).	Three activity cards were chosen every morning and displayed by the classroom door (see Fig 7.1). Activities were completed before morning break and lunch break as children lined up to leave the classroom. This was more of a bounce to the bell approach. Cards were sometimes used within lessons if children were getting restless or they needed a bit of a break.
Bounce at the bell	Deemed inappropriate as there were too many bells that go off in school for different class groups that can be heard by all.	Instead of using the school bell, the class teacher used an alarm sound from a phone which was played to initiate the jump routine. It was used predominantly in the afternoon when attention levels slipped.	Active classroom break cards used at break and lunch time 'bell'.
Born to Move videos	Videos were used for a whole school 'wake and shake' on Tuesday and Friday mornings immediately after registration.	The class went to assembly 15 minutes early to complete a video. The children tried to complete videos within the classroom environment, but only certain aspects could be done.	This school had more control over their PE lessons and videos were therefore used in PE lessons as an active warm up. Also used in breakfast club (not all children).
Physical activity homework	Attempts were made to hand out recording sheets on a weekly basis. Class teacher believed children lost interest after a few weeks due to having to repeatedly complete a daily recording sheet.	School employ a no homework policy. It was therefore implemented on a voluntary/optional basis and the teacher subsequently found it difficult to enforce. Not all children engaged.	School employ a no homework policy. It was therefore implemented on a voluntary/optional basis. A reward was handed out to the child who completed the most homework before the half term holiday.

	School 1	School 2	School 3
Daily Mile/100 Mile Club	100 Mile Club implemented twice a week during two afternoons that an additional member of support staff joined the class. Children collected counters from a member of staff after each lap of the playground was completed. School staff calculated how many laps/counters was equal to a mile. Children completed their recording sheet once they returned to class, tallying their miles and counters. A classroom display board was made (see Fig 7.2) so children could see their own progression.	Children went out to the playground 15 minutes before lunch time to complete their Daily Mile, 12.00pm. Afterwards they went straight into the dining hall to eat. Class teacher indicated that it wasn't daily but rather three times a week at a minimum.	Daily Mile was implemented predominantly in the afternoon period. It was also integrated into PE and swimming (class walk to facilities). Class teacher indicated that it wasn't daily, most commonly it was three times a week.
Playground activity cards	Activity cards not displayed.	Activity cards were tied to gates and fences around the playground. They began to look 'scruffy' after a few weeks because of weather conditions. Some initial engagement from children through curiosity but this wasn't sustained.	Activity cards were displayed on the inside of a classroom window visible on the playground. A CD player was placed by the window outside where children could do the activities to popular music played out loud. It was predominantly girls that engaged in these activities
Enhanced PE	Limited attempts to decrease sedentary time. Static stretching, elimination within games and whole class feedback.	Some aspects of the SAAFE framework ¹ and LET US Play ² principles adhered to. Organisation of equipment allowed for an immediate start. Space was maximised for small group sizes. Limited teacher involvement.	Some aspects of the SAAFE framework ¹ and LET US Play ² principles adhered to. Warm ups were active with limited static stretching and the class was split into small groups. Sedentary time increased with whole group feedback and the organisation of equipment within the lesson.
Newsletters	Messages were included in 3 parent newsletters in total. Fig. 7.3 show an example newsletter.	Messages were included in 3 parent newsletters in total. Fig. 7.4 show an example newsletter.	Messages were included in 6 parent newsletters in total. Fig. 7.5 show an example newsletter.

¹(Lubans et al., 2017). ²(Brazendale et al., 2015).

Figure 7.1. Activity cards displayed in the classroom by the door (School 3).



Figure 7.2. 100 Mile Club progress display in the classroom (School 1).



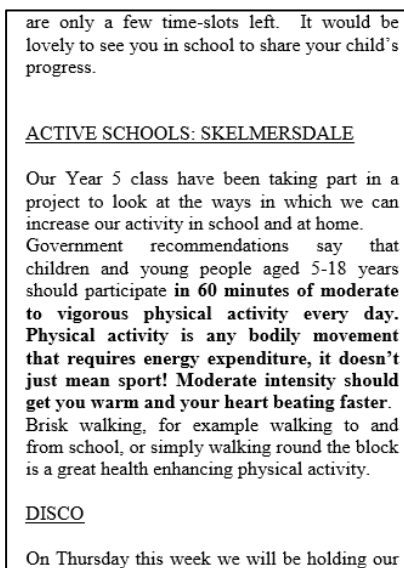


Figure 7.3. Parent newsletter in School 1 including an AS:Sk Health message.

Figure 7.4. Parent Newsletter in School 2 including an AS:Sk Health message.

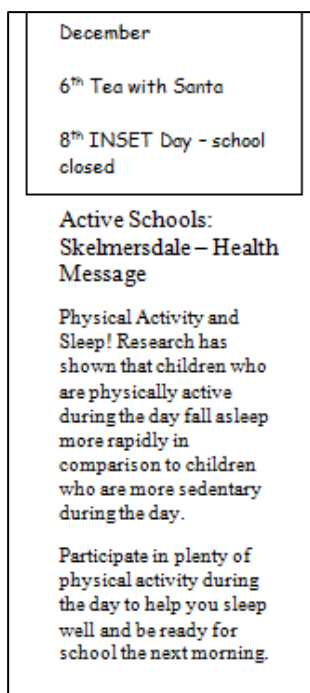
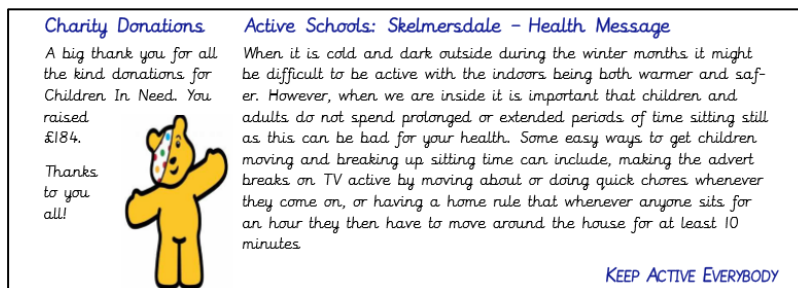


Figure 7.5. Parent Newsletter in School 3 including an AS:Sk Health message.

7.5.2 Child engagement

There were two sub-themes relating to child engagement. These were enjoyment and positive behaviour. Enjoyment was consistent across all four data sources. The intervention components reported by the children to be enjoyable to participate in were, the Daily Mile/100 MC ($n = 11$), Born To Move videos ($n = 4$), and ABs ($n = 1$). Positive behaviour was evident across all data sources apart from the researcher source, potentially because observations did not last long enough to see this particular sub-theme in practice. Evidence from each source relating to these sub-themes are presented in Table 7.4.

Table 7.4. Data sources for child engagement theme.

	Teacher	Child	WDST	Observations
Enjoyment	<p>“The more we got into it the more we enjoyed it. I thought it was absolutely great because it just gives the kids a bit of a break from learning and they loved it.”</p> <p><i>S3, F (BTM).</i></p>	<p>“They’re really fun because you don’t know what is coming next.”</p> <p><i>S2, F (ABs).</i></p>	<p>“I am doing the daily mile with my friend *child’s name* it is great fun”.</p> <p><i>S2, F (DM, Fig 7.6).</i></p> <p>“I did born to move, we are dancing to music and my body was moving and I enjoyed it.”</p> <p><i>S1, F (BTM, Fig 7.7).</i></p>	<p>There is good behaviour throughout all of the video, the teacher only speaks to encourage children. After the video finishes the teacher asks children to put their hand up if they enjoyed themselves, all children in the hall put their hands up in reply.</p> <p><i>S3 (BTM).</i></p>
Positive behaviour	<p>“They settle back down onto task and they seem to be more settled and keen to start their work.”</p> <p><i>S1, F (ABs).</i></p>	<p>“Your brain is awake. We do the active classroom break and then we go back into maths, but you know more.”</p> <p><i>S2, M (ABs).</i></p>	<p>“On the picture, we are doing our active classroom break. We all enjoy this and it really wakes us up.”</p> <p><i>S2, F (ABs, Fig 7.8).</i></p>	

F; Female. M; Male.

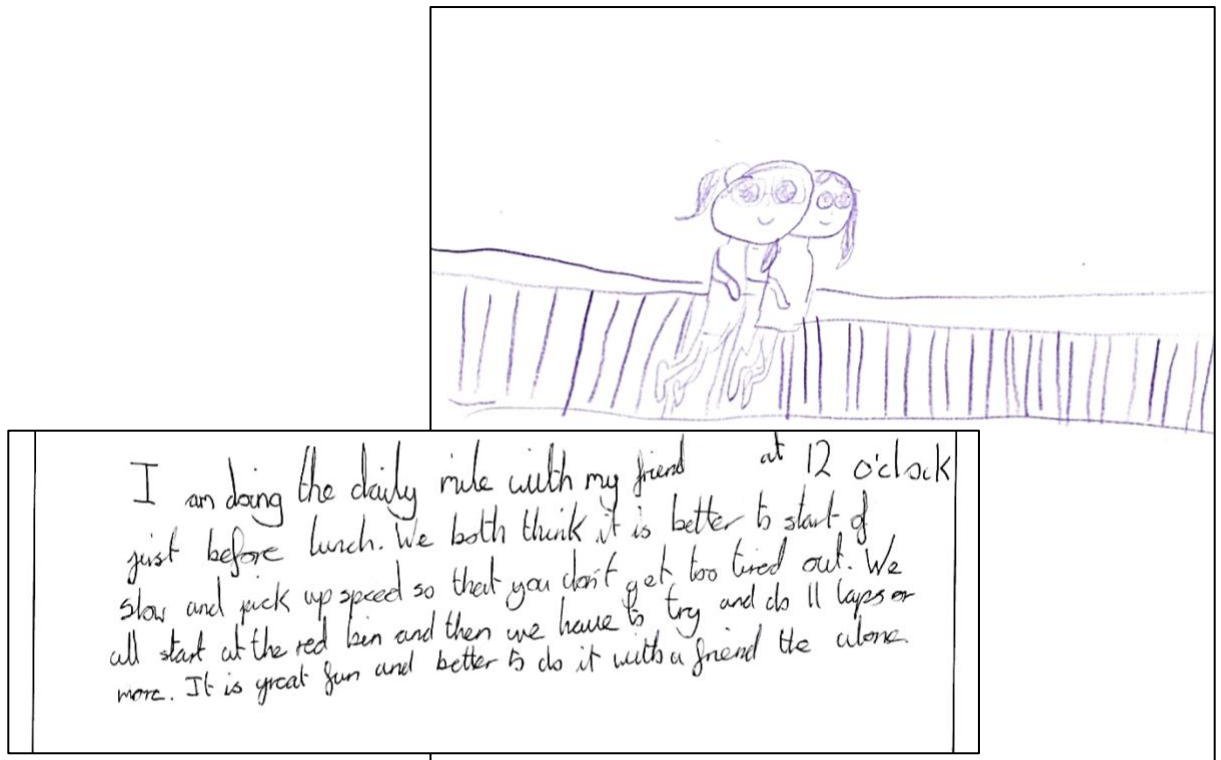


Figure 7.6. Drawing from a girl in School 2 illustrating the Daily Mile with her friend.

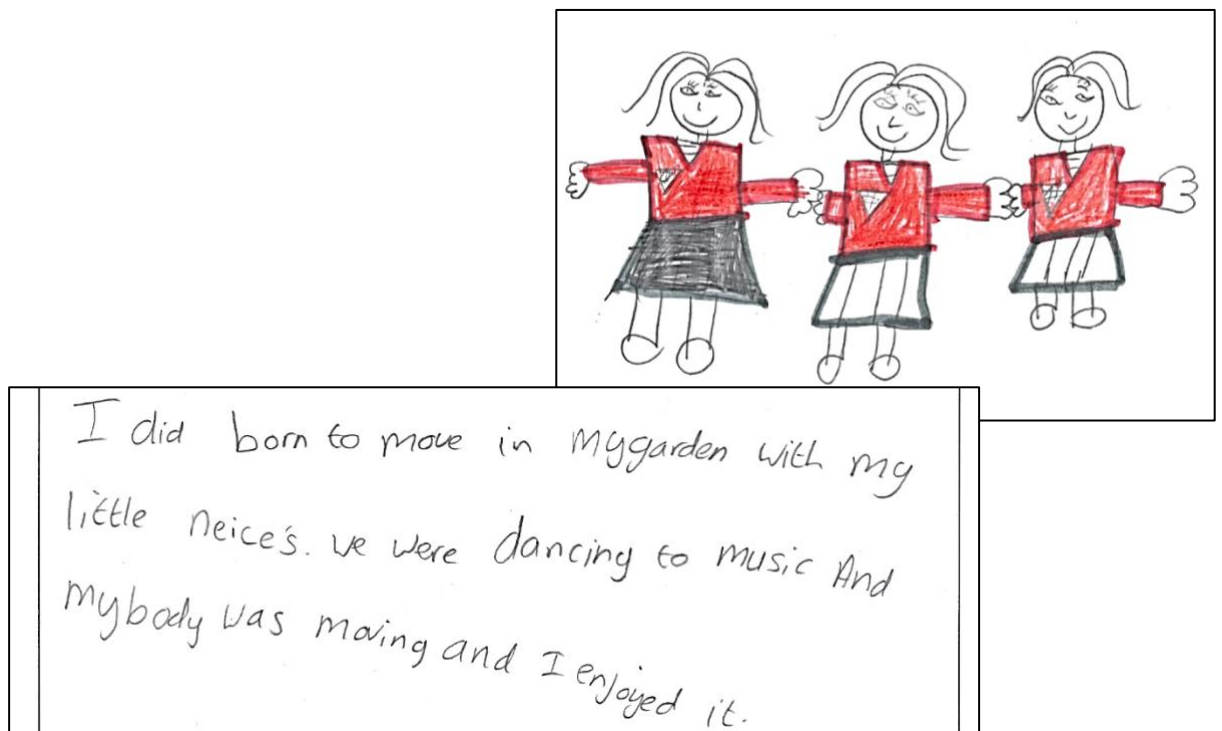


Figure 7.7. Drawing from a girl in School 1 illustrating enjoying Born To Move.

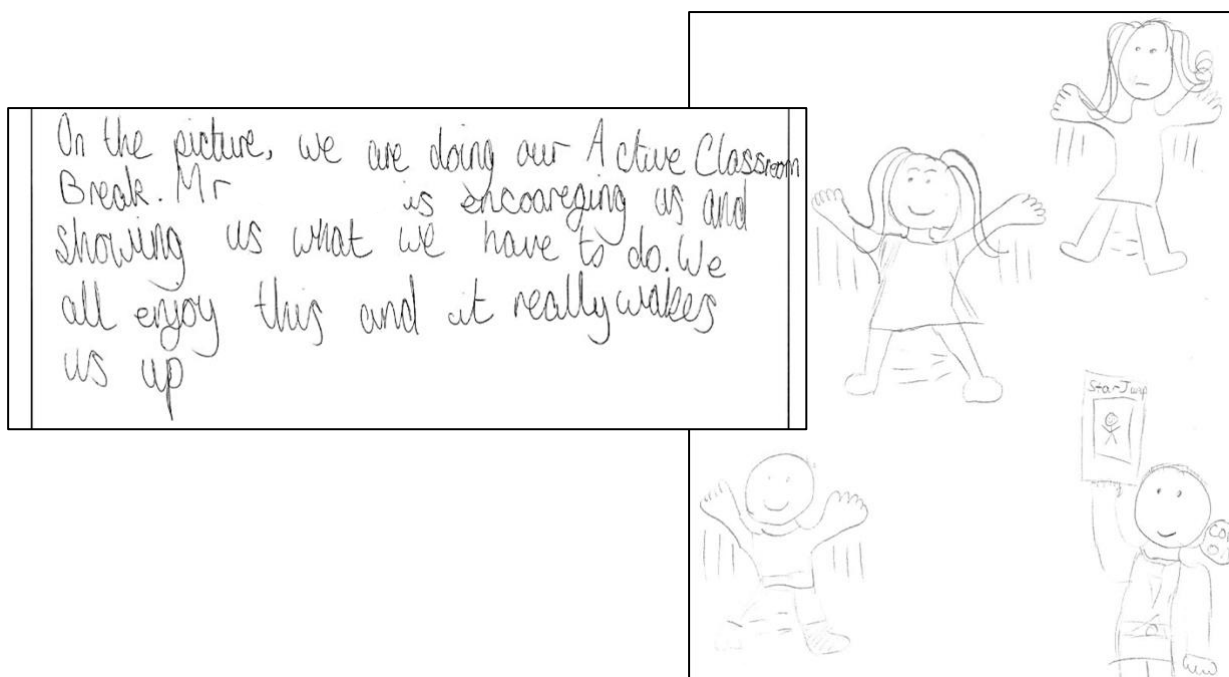


Figure 7.8. Drawing from a girl in School 2 illustrating taking part in active classroom breaks.

7.5.3 Facilitators

There were seven sub-themes relating to implementation facilitators. Evidence from each source relating to these themes are presented in Table 7.5. Peer influence, teacher influence, incentives, rewards, challenges, and competition, and routine were evident across all four data sources. A theme evident from teacher and child transcription but not child drawings was child ownership. Flexibility and adaptability was recognised by teachers, children and the researcher but was not evident in the children's drawings. This is understandable as this may be more difficult to convey in drawing format. Only one theme came from teachers alone and this was staggered implementation.

Table 7.5. Data sources for facilitators to implementation theme.

	Teacher	Child	WDST	Observations
Peer Influence	<p>"It's one of those where they get into groups and are like, right come on we'll do this. With friends it helps." S1, F (100 MC).</p>	<p>"It's a bit more fun because you've got your friends with you to do it." S2, F (DM).</p>	<p>"I'm doing the daily mile with my friend at twelve o'clock just before lunch. It is great fun and better to do with a friend than alone." S2, F (DM, Fig 7.6).</p> <p>"This is me and my class friends coming in from the 100 mile club run. We are all very tired." S1, F (100 MC, Fig 7.9).</p>	<p>Children run in small groups of 2-3, talking and laughing whilst they move. S2 (DM).</p>
Teacher Influence	<p>"If I get involved with them they start to laugh at it because when I was getting it wrong or my teaching assistant was getting it wrong when we were doing it, it became comical because they'd teach me it." S2, M (ABs).</p>	<p>"If the teacher is like, "you can do it", and then we say, "ok, you do it" and then he's like actually I can do it and it's a bit more encouraging." S2, F (DM).</p>	<p>"On the picture we are doing our active classroom break. *Teacher's name* is encouraging us and showing us what we have to do." S2, F (ABs, Fig 7.8).</p> <p>"Me, *child's name*, and *teacher's name* doing the born to move. I feel happy I like the actions." S3, F (BTM, Fig 7.10).</p>	<p>Throughout the video the class teacher is involved doing all the moves, when a child tells her they have a stitch she encourages them to carry on moving. S3 (BTM).</p>
Staggered implementation	<p>"Build it up gradually really, and sort of implement it a little bit at a time sort of thing." S1, F (General PA).</p>			

<p>Incentives, rewards, challenges, and competition</p>	<p>“They quite like to choose their favourite video sometimes. So that is a bit of an incentive I use with them, that they can choose if they reach certain milestones.” <i>S1, F (BTM).</i></p> <p>“They go, “Right I’m going to try and do more than you”. So that positive competition was good for them.” <i>S2, M (DM).</i></p>	<p>“I like the Daily Mile because I can challenge myself to not stop.” <i>S3, F (DM).</i></p> <p>“We do it to beat *child’s name* because she’s the fastest in the class. She beat a teacher in a competition.” <i>S2, M (DM).</i></p> <p>“I feel proud because I could have said, “No I don’t want to do it” but I did and I’m getting more done and I’ve got an extra mile.” <i>S1, F (100 MC).</i></p>	<p>“Me and *child’s name* are doing the daily mile in school. I enjoy doing the daily because I get a challenge so I make a big effort.” <i>S3, M (DM, Fig 7.11).</i></p>	<p>In the classroom after the mile run children are excited to complete their recording sheet. Teacher calls out names and children shout out how many miles they are up to, the teacher gives praise and their names are moved up the miles on the classroom wall display. <i>S1 (100 MC)</i></p> <p>After the run children tell their teacher how many laps they have done. One child doubled the amount of laps completed compared to the previous day and gets a round of applause from the class and will be pupil of the day the next day. <i>S2 (DM).</i></p>
<p>Flexibility and adaptability</p>	<p>“Sometimes if they’re keen, they’re on with their work, I don’t stop them, but sometimes when they get to a point and you can tell they’ve reached that point of “I need to do something different”, then we do it”. <i>S1, F (ABs).</i></p> <p>“They ended up loving head, shoulder, knees and toes, so we did that in several languages as we went through. Luckily my teaching assistant speaks multiple languages so that became comical.” <i>S2, M (ABs).</i></p>	<p>“We put our own twists to the activities.” <i>S2, F (ABs).</i></p>		<p>‘Shake it off’ exercise is the last to be performed in a 5 minute active break. The teacher has speakers and ‘Shake it off’ song by Taylor Swift ready to play. Children sing along and get a boost from the music to put greater effort in. <i>S2 (AB).</i></p>

Child ownership	<p>"Sometimes if we're busy with a child, explaining a concept or something, some of the kids will just take the lead and they will let the whole group do it". S3, F (<i>Bounce at the bell</i>).</p>	<p>"When *child's name* gets to pick which one, he's super enthusiastic." S2, F (<i>ABs</i>).</p>		
Routine	<p>"It became much easier, particularly with the mile a day. That was easy to be able to do. You know, quarter to twelve, twelve o'clock every day because that was just before lunch." S2, M (<i>DM</i>).</p> <p>"In the end it became much easier because it just became routine to have three, four things happening during the day most days." S2, M (<i>General PA</i>).</p>	<p>"You have English for an hour and you go out at twelve o'clock and just do it." S2, M (<i>DM</i>).</p>	<p>"I'm doing the daily mile with my friend at twelve o'clock just before lunch." S2, F (<i>DM, Fig 7.6</i>).</p>	<p>Children start to get ready to go outside after a class test at 11.58am, by 12pm children are on the playground running their mile. Once the run has finished after 15 minutes, children eating hot food from the school kitchen go straight into the dinner hall, children with packed lunches go back to the class room to get their food. Children didn't need direction or instructions after the run as to what to do next. S2 (<i>DM</i>).</p>

F; Female. M; Male.

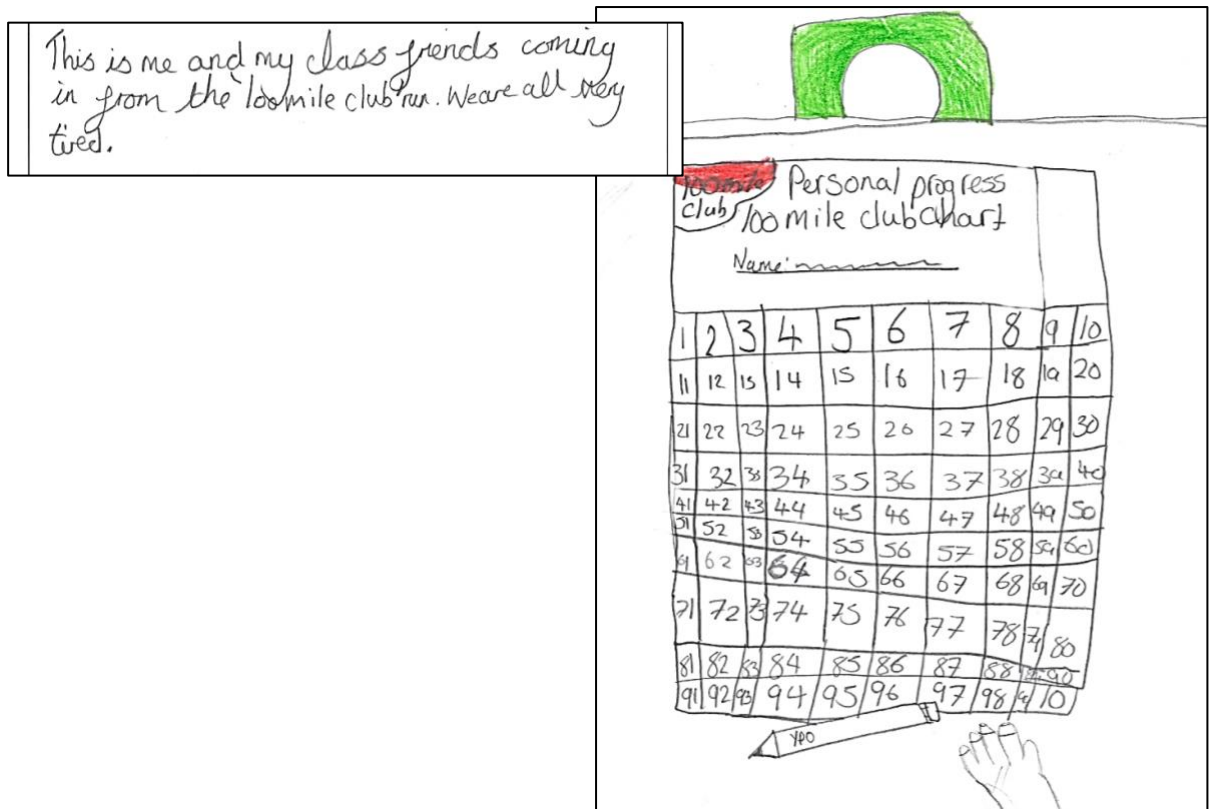


Figure 7.9. Drawing from a girl in School 1 illustrating taking part in the 100 Mile Club.



Figure 7.10. Drawing from a girl in School 3 illustrating taking part in Born to Move with her friends and teacher.

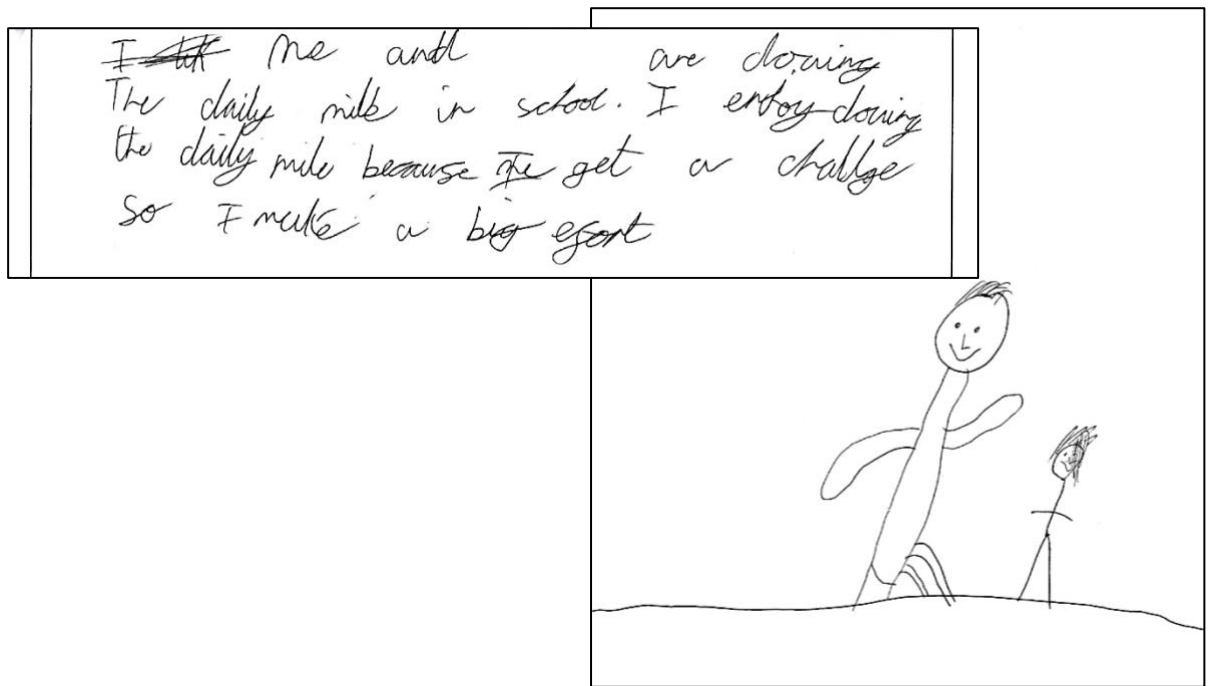


Figure 7.11. Drawing from a boy in School 3 illustrating taking part in the Daily Mile.

7.5.4 Barriers

There are five sub-themes relating to implementation barriers. These were: time within an intense curriculum, school space, sustaining interest, parental support, and school policies. Evidence from each source relating to these themes is presented in Table 7.6. Sustaining child interest and parental support referred to the PA homework component only and was consistent between teacher and child verbatim data. Both teacher and child verbatim data also highlighted the barrier of time especially within the intense curriculum. Space and school policies came from the teacher data source only. Researcher observations did not highlight any of these barriers most likely because they were conducted through pre-arranged visits.

Table 7.6. Data sources for barriers to implementation theme.

	Teacher	Child	WDST	Observations
Time within an intense curriculum	<p>“There are times where activity will just get knocked on the head, because I’ve got to fit everything in before Christmas, otherwise I’m going to be behind for testing at the end of the year. Next half term it’s pretty much maths and English and reading for them they don’t really have the creative side, the exercise side, the fun bit of education because it’s all test-based.”</p> <p><i>S2, M (General PA).</i></p>	<p>“In the assessments, when we were doing our last test we couldn’t do it.”</p> <p><i>S2, F (ABs).</i></p>		
School space	<p>“We’ve only got one hall slot per year group per week.”</p> <p><i>S3, F (BTM).</i></p>			
Sustaining child interest	<p>“They liked doing it initially but then they found after about four or five weeks, because it was repetitive, the same thing, they thought, “Oh Miss, it was getting a bit of a tedious task”, and the number of them completing it dwindled.”</p> <p><i>S1, F (PA homework).</i></p>	<p>“Sometimes you can forget to fill the sheet in.”</p> <p><i>S1, F (PA homework)</i></p>		
Parental support	<p>“A lot of the parents are at work so some of them say to you it’s even hard for them to sign a record for the kids this age so the lads do it themselves, but then you haven’t got parental support because the children are actually managing their own, so it’s a really big grey area and I’m assuming that happens in all schools.”</p> <p><i>S2, M (PA homework).</i></p>	<p>“My Dad is at work from very early in the morning to late at night.”</p> <p><i>S1, F (PA homework).</i></p>		
School policies	<p>“I couldn’t enforce it because we’ve sent a letter out to parents to say there’s going to be no homework other than learning spellings.”</p> <p><i>S2, M (PA homework).</i></p>			

F; Female. M; Male.

7.6 Discussion

This study aimed to combine the qualitative data collected from children, teachers and researcher observations within participating AS:Sk intervention schools to assess the implementation of multiple PA components within the school day. The review of school-based PA process evaluation literature conducted by Naylor and colleagues (2015) concluded by stating that the literature base was lacking in both quantity and quality. This study addresses the lack of quantity in the literature by completing a process evaluation study of a school-based PA intervention. Additionally, this study addresses the lack of quality as multiple approaches were used to understand implementation from the perspective of the researcher, teachers and children including the novel technique of WDST. Despite this, quality was still lacking due to the absence of quantitative data.

Four themes emerged from the data. Implementation methods included sub-themes of how and when teachers implemented components. Child engagement with the intervention included sub-themes of enjoyment and positive behaviour. Another theme was the facilitators to implementation which included peer influence, teacher influence, staggered implementation, incentives, rewards, challenges and competition, flexibility and adaptability, child ownership, and routine sub-themes. Finally, barriers to implementation included sub-themes of time within an intense curriculum, space, sustaining interest, parental support, and school policies.

7.6.1 Implementation Methods

ABs were most commonly implemented at the start or end of a lesson. Teachers also deemed ABs useful for breaking up a lesson or transitioning from one subject to

another. The use of ABs at the end of an academic lesson has been reported by other teachers who implemented them as a reward for children after academic engagement (McMullen et al., 2014). One school used the AB activity cards combined with the bounce at the bell component, i.e. three AB activity cards were completed before the start of morning and lunch break (instead of the prescribed jumping routine for bounce at the bell). Bounce to the bell in its prescribed format was not implemented by any schools. Conversely, in a previous bounce to the bell intervention study it was deemed to be an exercise programme that could be easily implemented and compliance with 10 jumps completed three times a day, ranged from two days to five days per week (McKay et al., 2005). Bounce to the bell was adapted in one school to be used during lessons to get children's attention with a teacher implemented bell noise that initiated a jumping routine, usually once per afternoon.

BTM videos were successfully implemented twice per week in one school with a whole-school (all age groups) approach, and were used within PE lessons in another school. Two schools implemented the DM, although both struggled for this to happen every day. One school had a set time every day (just before lunch break) but the other implemented whenever necessary, which was commonly in the afternoon. The remaining school chose to implement the 100 MC. This occurred twice a week and the number of laps needed for one mile were calculated, with children collecting a counter after each playground lap completed. Individual child records of laps and miles completed were kept and updated after every run.

Playground activity card engagement was limited and the weather conditions deteriorated the quality of the cards. This component was most successful in a school

that displayed the cards on the inside of classroom window with music playing. Within PE lessons there was some evidence of attempts to decrease stationary and sedentary time but this was limited. In a study including a full-day professional learning workshop for teachers, more systematic observations indicated that teachers adhered to between 62.9% and 79% of recommended PE lesson structures or techniques to enhance MVPA (Cohen, Morgan, Plotnikoff, Callister, & Lubans, 2015). Teachers found the PA homework difficult to sustain due to interest levels of children which reduced with time. Finally, all schools posted PA messages within their newsletters (minimum of three messages) which were circulated to parents.

7.6.2 Child engagement

The sub-themes of enjoyment and positive behaviour within the child engagement theme are consistent with Study 2 of the AS:Sk project and also other school-based PA interventions (Howie, Newman-Norlund, & Pate, 2014; Martin & Murtagh, 2017; Nathan et al., 2017). Fun and enjoyment in particular have been outlined as key areas of focus for PA promotion in young people and is a predisposing factor for PA participation in the YPAPM (van Sluijs & Kriemler, 2016; Welk, 1999). Given that child enjoyment and positive behaviour are consistently appearing in the literature as benefits of school-based PA, they should be key factors which are used in future studies to help engage schools, head teachers, and class teachers. Enjoyment is a stable and consistent psychological construct which predicts PA participation and PA participation has been shown to have a positive effect on academic behaviours, including better attention and on-task behaviour (Best et al., 2017; Sullivan, Kuzel, Vaandering, & Chen, 2017).

7.6.3 Barriers to implementation

Five sub-themes were reported by teachers in relation to barriers which prevented implemented and subsequently will have impacted the efficacy of the AS:Sk intervention within participating school. Time within a crowded curriculum was cited by teachers as a reason for having to omit intervention components and PA in general, within the school day. Children were also aware of time pressures particularly when they had assessments for example. Time was reported as a barrier in Study 2 of the AS:Sk project, which is consistent with previous school-based intervention implementation literature (Campbell et al., 2015; Naylor et al., 2015; Naylor et al., 2010). High intervention fidelity was reported in a healthy lifestyles programme to prevent obesity, as education intervention components were compatible with the National Curriculum and did not displace teaching time (Lloyd et al., 2017). For PA components (rather than educational components) this may be a more difficult task, although the integration of movement with academic outcomes has received more attention in the literature recently (Martin & Murtagh, 2017b; Riley et al., 2017). Despite this active learning approach, teachers have still reported time as a barrier to the delivery and implementation of such movement integration strategies (Routen et al., 2018). Physically active lessons are often short-lived (Quarmby, Daly-Smith, & Kime, 2018). If this approach to PA promotion is considered, attention should be given to the barriers which impact teachers' ability and willingness to implement physically active lessons, from individual, interpersonal, institutional, and community level perspectives (Quarmby et al., 2018). Furthermore, both teachers and children alike spoke positively about ABs as a means for a short break from academic content. Teachers have previously reported that ABs can be fitted into schedules without

disrupting academic lessons (Carlson et al., 2017). When considering the barrier of time within classrooms for PA strategies, ABs may not always be viewed negatively as an activity which takes time away from the curriculum by teachers.

Time was cited as a barrier for the intervention as a whole, but more commonly teachers referred to time when discussing intervention components that were required to be implemented outside of the classroom for example completing a mile run or an active video. These intervention components were also limited by the barrier of school space. Once more this barrier of space was reported in Study 2 of the AS:Sk project, which is something that has previously been observed in school-based PA interventions (Jago et al., 2015). Teachers reported attempting to complete BTM videos within the classroom due to not being able to access the hall/gym, and overall it appears that classroom-based activities increase feasibility of implementation. Previous teacher data have also highlighted the need for PA programmes to be classroom-based without it being necessary for children to get to another location within school (van den Berg et al., 2017). However, when considering the intervention components children reported as being most enjoyable, the two most common were activities outside of the classroom (DM/100 MC and BTM videos). Thus within the school environment a compromise between child enjoyment and teacher feasibility is evident and the importance of gaining perceptions from both children and teachers is highlighted. Whilst children may find activities outside of the classroom in a different environment more enjoyable to participate in, teachers face more difficulties in trying to implement these types of activities.

7.6.4 Facilitators to implementation

One participating school was able to consistently implement BTM videos twice a week without space or access to the hall/gym acting as a barrier. This was facilitated by implementation occurring with the whole-school (all age groups) with completion of an active “wake and shake” together at the same time. This was the only evidence of a whole-school approach across the participating schools and intervention components. A whole school approach to intervention component implementation was not something which was recommended to schools as the primary focus was with the Year 5 classes only. However, within this particular school they decided that a whole school approach was both feasible and most appropriate when it came to implementing the BTM videos. Having all children participating at the same time may not be possible for larger schools, however this approach should be considered in future school-based interventions, where feasible. Rather than competing for school space, teachers were able to use the space together with a shared vision for increasing PA, and this supportive school climate has been identified as a key factor in a systematic review of implementation literature (Naylor et al., 2015). Head teachers have also previously stated that activities including the whole school make it easier to manage effectively within a school environment (Christian et al., 2015).

Teachers also referred to routine as a facilitator to implementation. Teachers believed that eventually the intervention components became part of their routine, and this was facilitated by a staggered implementation of components so not to initially overload the timetable or children with activity. Additionally, in School 2 for example, having a routine with the DM and consistently completing it at the same time of the school day also aided implementation. That being said, teachers reported that

flexibility to implement whenever best suited the class was also important and this has been reported as a facilitator in previous studies (Naylor et al., 2015). Head teachers have also stated that interventions with a flexible approach are useful within primary schools (Christian et al., 2015). Furthermore, teachers adapted intervention components from their prescribed format to also best suit their class. Previously, ineffective outcomes have been associated with programmes not being implemented as intended (Durlak & DuPre, 2008). However, the school setting is dynamic in nature with constant change to schedules for example, and researchers should consider this when evaluating interventions. If schools are compromising on intervention fidelity this may not always be a failure of the intervention. For example, if changes are made by schools to intervention prescription to make strategies work best for their individual circumstances, PA could be more likely to occur within the school day. This flexibility and adaptability were reflected in reports of adding incentives, rewards, challenges, competition, and child ownership which all facilitated implementation and child engagement.

Two reinforcing factors of the YPAPM model were consistently reported by both children and teachers alike, these were peer and teacher influences (Welk, 1999). Teachers recognised that children preferred to do PA with their friends, and children echoed these thoughts by saying activities were more fun with their friends taking part with them. Previous research has indicated that friends' PA levels can have a significant influence on an individual's PA level and has recommended that future interventions consider encouraging friends to be active together (Jago et al., 2011; Sawka, McCormack, Nettel-Aguirre, Hawe, & Doyle-Baker, 2013). Teacher involvement included verbal encouragement and also taking part in some of the

activities with children recognising the encouragement in particular to make them try harder. The pivotal role which teachers play was highlighted by the Fit-4-Fun study which resulted in increased PA levels which were mediated by teacher support (Eather, Morgan, & Lubans, 2013).

7.6.5 Strengths and Limitations

The main strength of the current study is the multiple sources from which data were collected. Perspectives from teachers via interviews, children via WDST/focus groups, and the researcher via observations, helped to provide a comprehensive picture of the intervention and how it was implemented. Furthermore, the triangulation of data methods enhances credibility. The use of a novel approach to explore the perceptions of participating children via the WDST method is also strength of the study. This approach provides children with alternative options for expression which can help to foster greater inclusivity and elicit more representative perceptions. Also, the WDST framework which begins with a simple task that children can answer easily (i.e. writing down their favourite intervention component and telling the group) helps to place children at greater ease. Thus, children have desire to engage and open discussions are stimulated. A limitation of the current study is the small number of schools that participated. This number was reduced further due to missing data and consequently exclusion of one of the original intervention schools due to unforeseen reasons. Although the circumstances of this school were unique, with staffing changes mid-intervention, increased communication between teachers and researcher may have inhibited the missing data which resulted from the situation. On the contrary, it was difficult for the researcher to intervene and it reflects just one of the many

complications which researchers can face when collecting data in a real world setting of a school.

A further limitation is the lack of quantitative data collected, as recommended in the MRC guidelines for the process evaluation of complex interventions (Moore, Audrey, Barker, Bond, Bonell, Hardeman, et al., 2015). Resultantly, there is a limited understanding on specifically how often each intervention component was implemented week by week. Although teachers indicated how often components were implemented this relied on teacher-recall over an eight-week period to provide a general picture of how the intervention was implemented, rather than specific frequencies. Initially, recording sheets were given to teachers for the eight weeks of the intervention period and teachers were reminded to complete these sheets to indicate how often they had implemented each component per day. However, teachers reported that they would often forget to complete and/or lose recording sheets. Teachers most commonly 'forgot' because of the limited time they had to complete other teacher related administrative tasks, again highlighting the difficulties of school-based research. In a previous school-based intervention that used weekly log sheets, adherence of completion was low (34% of eligible weeks) (Naylor et al., 2010). Whilst attendance records are a feasible method for measuring uptake to after-school clubs or workshops for example (Lloyd et al., 2017), more consideration is needed for a feasible method to track school-based interventions throughout the implementation period.

7.7 Conclusions

This process evaluation of the AS:Sk study demonstrates that, in schools time is a barrier to PA that both teachers and children were aware of. Because of limited time and space, classroom-based activities may be most feasible and acceptable for teachers to implement, although children reported that the activities outside of the classroom were most enjoyable. This highlights the compromise that is needed within school-based PA interventions to accommodate components which *children will want to participate in* and which *teachers can feasibly implement* within the school day. Also, a whole-school approach with teachers working together with multiple year groups to implement PA may help, particularly by removing the barrier of competing for space. However, schools may struggle in finding complementary times between different timetables. Future interventions should aim to achieve a balance between PA being implemented at consistent specific time points in the school day, whilst also having capacity for PA components to be flexible and adaptable so that they can suit the individual needs of specific classes. Enjoyment of PA and the positive effect it can have on child behaviour are important ‘selling points’ to schools and school staff to encourage future participation in PA interventions and overall engagement in school-based PA.

Thesis Study Map

Study	Objectives and Key Findings
Study 1: Predictors of Segmented School Day Physical Activity and Sedentary Time in Children from a Northwest England Low-Income Community	<p>Objectives</p> <ul style="list-style-type: none">• Establish the current MVPA and ST levels of children aged 9-10 years who attend schools in a low-income town of Northwest England.• Investigate the child and school-level influences on children's PA and ST during segmented school hours. <p>Key Findings</p> <ul style="list-style-type: none">• On average both boys and girls did not achieve the recommended 60 min of MVPA on average. School-based PA interventions are warranted.• Significant child-level predictors were maturity offset, CRF, weight status, WtHR, ST, and MVPA.• Significant school-level predictors were number of children on roll and playground area.
Study 2: Acceptability and feasibility of single-component primary school physical activity and sedentary behaviour interventions to inform the AS:Sk Project	<p>Objectives</p> <ul style="list-style-type: none">• Investigate the feasibility and acceptability of single-component school-based PA interventions.• Evaluate the effectiveness of single-component school-based PA interventions on levels of school-based MVPA and ST. <p>Key Findings</p> <ul style="list-style-type: none">• Implementation challenges related to space within the school environment, competing demands of teachers and other members of staff, such as timetable constraints and other responsibilities.• The AB and BTM interventions indicated some positive effects on levels of MVPA and ST.

<p>Study 3: Evaluation of a Pilot School-Based Physical Activity Clustered Randomised Controlled Trial — Active Schools: Skelmersdale</p>	<p>Objectives</p> <ul style="list-style-type: none"> • Evaluate the effectiveness of the AS:Sk multi-component intervention on levels of school-based MVPA and ST. <p>Key Findings</p> <ul style="list-style-type: none"> • The AS:Sk multi-component intervention had a significant effect on school day ST (significantly less for intervention children by 9 min per day compared to control group). • There were no intervention effects for PA outcomes.
<p>Study 4: The process evaluation of Active Schools: Skelmersdale: a pilot school-based physical activity clustered randomised controlled trial</p>	<p>Objectives</p> <ul style="list-style-type: none"> • Explore how the AS:Sk multi-component intervention was implemented in participating schools. • Investigate the feasibility and acceptability of the AS:Sk multi-component school-based PA intervention. <p>Key Findings</p> <ul style="list-style-type: none"> • Emerging factors for consideration in future school-based PA strategies included, time, space, and child enjoyment. • Implementation differed between schools. • Study findings advocate school-based PA strategies that are flexible and adaptable in nature.

Chapter 8: Synthesis of Findings, Strengths and Limitations, Recommendations and Conclusions

8.1 Synthesis of Findings

It is important that CYP engage in sufficient PA to achieve and maintain both physical and psychological health (Ahn & Fedewa, 2011; Janssen & LeBlanc, 2010; Poitras et al., 2016). Government recommendations state that CYP should be engaging in at least 60 minutes of MVPA per day (Chief Medical Officer Department of Health, 2011). Objectively collected data indicates that these recommendations are not being met by a significant proportion of youth (80% of 12-15 year olds globally) (Hallal et al., 2012). Schools have been outlined as a key environment for PA promotion and engagement in youth and recent recommendations state that at least 30 minutes of MVPA should be accrued within school (HM Government, 2016).

Previous school-based PA interventions have shown promise for positively effecting PA levels, particularly those which are multi-component in nature (Burns et al., 2015; Murillo Pardo et al., 2013). However, maintenance of these effects is questionable once the intervention period concludes (Gorely et al., 2011; Harrington et al., 2018). To meet school-based PA guidelines, schools require strategies that can be sustained without the need for external bodies and significant amounts of funding. In an attempt to fill the research gap, this thesis included four school-based studies that explored novel school-based PA strategies which were implemented by existing school structures with no financial costs and were evaluated with robust quantitative and qualitative methods.

The studies conducted as part of this thesis were theoretically underpinned by three conceptual models. The socio-ecological model (McLeroy et al., 1988), YPAPM model (Welk, 1999), and the TEO (Beets et al., 2016) ensured that the studies considered a

range of multidimensional influences on children's PA and developed school-based PA strategies which were appropriate for use.

This final chapter of the thesis will summarise the findings of each study and synthesise them in relation to the existing literature base. The overall strengths and limitations of the thesis will then be discussed. Finally, the findings of the thesis and how they should be used to inform future practice and research are explored.

Traditionally, previous research has examined correlates of children's PA within a broad whole-day and whole-week perspective without consideration of the specific environments in which it takes place (Sterdt et al., 2013). **Chapter 4 (Study 1)** considered a broad range of individual and school-level influences on children's PA and ST levels, more specifically and distinctively, during school segmented hours only. Results were consistent with previous research. For example, greater maturation status significantly predicted less MVPA during the school day, morning break, and PE with previous research establishing this disengagement from PA with maturation (Cumming, Standage, Gillison, & Malina, 2008). School-level predictors were more inconsistent but included number of children on roll and playground area. The study results help to expand the current knowledge base by establishing specific factors of influence on school-based PA engagement. This is important as the school environment is regarded as a place where children can engage in PA regardless of individual circumstances (Naylor & McKay, 2009). Although the importance of the school environment for PA promotion is not undermined, the results did however highlight that it may not be as simplistic enough to suggest that because all children

attend school they will therefore all have equal opportunities to engage in PA during school hours.

Chapter 4 (Study 1) established that overall PA levels of children living in the low socio-economic target area were low across the whole day and school day, thus confirming that interventions targeting various parts of the school day were warranted. Therefore, **Chapter 5 (Study 2)** explored some initial single-component school-based PA ideas. School involvement was key in this initial intervention implementation phase. Consideration of the school day segmented PA levels presented to schools informed their selection of one intervention component to implement for a four-week period. This method of school choice was consistent with previously successful school-based PA interventions (Blom et al., 2017; Naylor et al., 2008). The prominent strength of this chapter was the use of qualitative and quantitative data sources, which allowed for a comprehensive understanding of each intervention strategy to be gained. For example, understanding whether strategies were feasible for teachers to use within the school day and whether strategies were successful at positively impacting PA levels. This adheres to the MRC's guidance for developing and evaluating complex interventions, which advocates the combined use of qualitative and quantitative methods when assessing feasibility (Craig et al., 2008). Furthermore, the quantitative and qualitative data collected were used to inform the subsequent work of the thesis. This enhances the current literature research base as it has previously been stated that there are few examples of early engagement with qualitative research to influence intervention research (Cathain, Thomas, Drabble, Rudolph, & Hewison, 2013).

Based on the PA outcomes of Chapter 5 (Study 2), the ABs and BTM videos were effective. Qualitative data suggested that the ABs were feasible to implement, whereas the implementation of daily BTM videos and teacher initiated playground activities were prevented by numerous barriers. For example, recess may be one of the most obvious segments of the school day which can be targeted for increasing MVPA, but teachers believed that older children such as those in the current programme of research (ages 9-10 years) preferred to be independent during this time period. This proposes difficulties for being able to positively affect PA levels, particularly via teacher influence. The importance of qualitative data in school-based research is emphasised. For example, PA data showed that daily BTM videos were effective for providing additional MVPA, however without the qualitative data it would not have been known that important barriers existed, such as space and time, which were key for implementation. Researchers have advocated integrating the views of those expected to deliver and participate in interventions to the research process (van Sluijs & Kriemler, 2016).

The findings of Chapter 5 (Study 2) informed the formulation of the AS:Sk multi-component school-based PA intervention which was implemented and evaluated in **Chapter 6 (Study 3)**. Adaptations were made to the BTM and playground intervention strategies and they were then combined with the ABs and four other school-based PA strategies. The AS:Sk multi-component intervention was effective in decreasing school-day ST. Results also revealed favourable changes in school day LPA, PA, MVPA, and CRF, though these were not statistically significant. There were also no significant intervention effects on whole weekday movement behaviours (including out of school

hours). School-based PA interventions should not disregard the after-school period. The PA homework of the AS:Sk intervention was not sufficient to positively impact out of school PA. Additionally, this homework approach may be less suitable than previously thought (Claxton & Wells, 2009; van Sluijs et al., 2007), as many teachers reported that homework was very limited and often no longer existent due to new school policies. School-based extra-curricular PA may be more impactful than PA which requires children's engagement in the home environment. This after school period is however more complex in terms of barriers to participation. Example barriers to PA which the school day period helps to eliminate, but which would become influential in the after school period include, parental support, and teacher availability for implementation/support.

A key and novel aspect of the intervention was the flexibility which schools were provided with in terms of timing of delivery. This meant that intervention components could be embedded into the timetable when it best suited teachers. This does however raise an implementation related discussion. Differences in implementation between participating schools can be viewed two-fold. Firstly, that differences in implementation frequency between schools likely impacted the results of Chapter 6 (Study 3). Secondly, that this flexibility however influential on results, is needed in the "real-world" school setting in which unpredictable changes to timetables can happen for example. Programme flexibility has previously been reported by teachers as a facilitator to implementation (Naylor, Macdonald, Zebedee, et al., 2006). It is evident that implementation is key and this statement has been supported elsewhere, with

the measurement of implementation outcomes deemed critical for the evaluation of PA programmes (Shah et al., 2017).

The conclusion of Chapter 6 (Study 3), stating that process evaluation research is advocated for focusing on how to improve the implementation of established PA school-based techniques provided a clear rationale for **Chapter 7 (Study 4)**. Within Chapter 7 (Study 4), a strength and unique aspect of the research was the combination of qualitative data collected from children, teachers and researcher observations within participating AS:Sk intervention schools. These sources of data allowed for the implementation of multiple PA components within the school day to be evaluated. Results were largely supportive of Chapter 5 (Study 2) findings and previous research, with some emerging factors for consideration in school-based PA strategies including, time (Campbell et al., 2015), space (Jago et al., 2015), and child enjoyment (Nathan et al., 2017). Exploration of the intervention components implementation revealed individual school adaptations were made. Identical component implementation between schools was a rarity, whether these differences were in terms of timing within the school day or delivery style. Adaptations to delivery were reported, such as singing along within ABs which helped to make them more enjoyable. Teachers making adaptations to make PA more fun for children is of great importance as enjoyment is a key predictor of PA participation and adherence (Teixeira et al., 2012). Overall, Chapter 7 (Study 4) results suggested that compromises to intervention fidelity occurred. If schools are compromising on intervention fidelity this may not always be a failure of the intervention. If changes are made by schools to intervention prescription to make strategies work best for their individual circumstances, PA could

be more likely to occur within the school day. Thus, the study findings advocate school-based PA strategies that are flexible and adaptable in nature.

Study 4 highlighted the importance of conducting process evaluation studies and the information it can shed light on which PA outcomes alone are not able to do. As a result of the study outcomes, recommendations for future interventions were made such as the need for flexibility and adaptability. Furthermore, the process evaluation study highlighted how schools differently implemented strategies despite using and receiving the same information and resources to do so. Educational, school-based research is highly influenced by context which differs significantly from school to school such as personnel, teaching methods, budgets, leadership, and support (Berliner, 2002). Therefore, qualitative inquiry or process evaluations are required to further understand school contexts (Berliner, 2002). In order for school-based PA strategies to work they need to be appropriate for use within the dynamic and busy setting of a school and a school classroom. Therefore, process evaluations are of greatest importance for researchers who are seeking to plan and implement school-based PA interventions. Researchers should draw upon process evaluation studies to gain an understanding of strategies which have been deemed appropriate for use in the school setting.

Process evaluations and measurements of implementation are still in their infancy in the field of PA intervention research (Naylor et al., 2015). This was reflected in the difficulties experienced in Chapter 7 (Study 4) when attempts were made to gain an accurate and objective record of implementation frequency across the eight-week period within each participating school. Daily researcher visits during the intervention

period were not possible due to the time constraints of the researcher. Alternatively, attempts were made to utilise teacher logs but these were incomplete because teachers reported forgetting to complete them or losing them. Although research has advocated process evaluations, and their importance has been highlighted to aid interpretation of outcome data (Durlak & DuPre, 2008), completion of such research can be fraught with obstacles, particularly in the school environment.

8.2 Strengths and Limitations

Given that study-specific strengths and limitations have already been discussed in each chapter, this section will discuss in more detail the main strengths and limitations that were consistent across the whole programme of research.

8.2.1 Physical activity measurement

PA was assessed using device-based measures throughout the programme of research. It is common for studies to utilise simple measures such as PA recall questionnaires. However, subjective self-reported methods have potential for error when asking a participant to recall PA over a long period of time (Nusser et al., 2012). Conversely, a questionnaire asking shorter recall may not be an accurate measure of long-term behaviour (Nusser et al., 2012). More specifically, difficulties associated with the use of questionnaires with children include quantifying duration, frequency and intensity of activities (Sherar et al., 2011). Accelerometers can precisely obtain this type of information. Therefore, accelerometer use is believed to have strengthened study outcome accuracy. Most commonly used outputs from accelerometers are counts which are dependent on internal proprietary algorithms (Welk et al., 2012). Uncertainties of pre-processed count data include the possibility

that signal filtering methods can alter study results (Freedson et al., 2012; Peach et al., 2014). Subsequently the use of raw accelerations across the programme of research avoids these uncertainties and was a further strength. That being said, the use of raw data is still in its infancy and the increased control which researchers can have over this form of data means that there is a lack of consensus over the procedures. As the use of raw acceleration data processing continues to grow, so too will the consensus and consistency of processing methodology. Although intensity threshold cut-points are based on indirect calorimetry research, corresponding to MET values (Hildebrand et al., 2014), and are device and placement specific, these figures may also continue to change as the research develops. The use and development of raw PA data analysis within future research requires increased consistency of intensity threshold cut-points. Once the research field reaches this stage and consistency improves, there will be increased opportunities to compare between study outcomes which use different devices for example (Hildebrand, Van Hees, Hansen, & Ekelund, 2014). Alternatively, future research using raw PA data outcomes may move away from cut-point thresholds to avoid any uncertainties of PA classification. The variation in available cut-points has been a catalyst to explore strategies such as metrics which can describe intensity distributions of accelerations over a 24 hour period (Rowlands, Edwardson, et al., 2018).

8.2.2 Methodological approach

The intervention phases of Chapters 5-7 (Studies 2-4) were strengthened by the mixed methods approach in which PA was objectively collected and qualitative views of teachers and children were also collected. This methodological approach adheres to

MRC guidelines for the development and evaluation of complex interventions in which the use of qualitative and quantitative methods are encouraged (Craig et al., 2008). Quantitative methodologies are most useful for testing effectiveness but cannot identify mistakes, limitations or unintended consequences of PA strategies which can influence effectiveness outcomes (Beltran-Carrillo et al., 2017). Learning from the target population (children and teachers) and incorporating evaluation techniques based on qualitative approaches can attend to this gap in evaluative knowledge. The insight provided from qualitative data is an important complementary contribution to the research base, particularly when combined with quantitative methodologies (Beltran-Carrillo et al., 2017). For example, quantitative outcomes may suggest that a programme is successful at having a positive effect on PA outcomes which is important for health indicators. However, if the same programme did not align with school needs or was deemed unfeasible in every day school practice, it would not be sustained in the long-term and the most appropriate way to discover this would be through qualitative methods. The results of the current programme of research advocates the further use of both quantitative and qualitative methods in school-based PA intervention research to better understand strategies which are both effective and also feasible.

8.2.3 Passive Consent

The use of passive consent to collect child data for studies 2, 3, and 4, was a major strength of the thesis and can subsequently have implications for future research. In previous school-based PA research there is only a limited number of studies that have utilised passive consent. In particular, the only other study to the knowledge of the

author, which has used passive consent within an evaluative study of a school-based PA intervention in UK primary schools is the 'Active for Life Year 5' project (Kipping et al., 2014; Lawlor et al., 2011). The AS:Sk project can be used as a further example of passive consent being used to strengthen any future ethical applications.

The use of passive consent requires a set period of time in which parents and carers have the opportunity to withdraw their child from participating. Despite this, it can significantly reduce the amount of time which is required in the timescale of research projects, as the use of active consent can often take longer than what is originally planned. The burden placed on school staff to retrieve consent forms is also significantly reduced. This is of great importance for school-based research in which timescales can be difficult to plan and align with school term times and holidays. For these reasons, the use of passive consent had a significant impact on the thesis and ultimately allowed for the number of studies to be conducted in the given time period.

A consideration for researchers when using passive consent is the possibility that you may have to prepare for data collection sessions without knowing how many children will be taking part. This can have implications for the number of accelerometers you would need to initialise for example. Receiving class lists from schools may not always be an easy task but can help to eliminate this problem.

Ethical considerations for using passive consent particularly in high deprivation communities include the possibility that English may not be the first language of some parents or carers. This was highlighted in the literature review, as within the target area of Skelmersdale for this thesis, there is community of Eastern Europeans for example (National Statistics, 2012). Researchers should take advice from school head

teachers. Whilst head teachers may agree to passive consent to reduce burden for their staff, it is unlikely that any head teacher would approve the approach if they felt that it was unethical for their pupils, parents and carers. Furthermore, researchers should seek the written support from head teachers to strengthen their ethical applications.

8.2.4 Sample size

Seven schools in total were recruited to be involved in each study. Twelve schools initially expressed an interest in the project which could have increased participant numbers. However, these additional five schools declined through reasons relating to insufficient time and recruitment/consent issues. Stronger attempts could have been made to persuade these schools to participate but a range of factors were influential to this not being possible. Firstly, these schools will have never previously been invited to take part in a large-scale university research project, primarily due to their location. Resultantly, the research project was initially received with large amounts of uncertainty from senior school staff, and although this was overcome in the final seven participating schools it required significant time and effort as highlighted in the recruitment discussion of Chapter 3. Secondly, the project was limited by the resources available, for example access to accelerometers, research staff to collect data and also time available. Subsequently, seven schools were at the upper limit of what was achievable. It is recognised that the small sample sizes throughout is a limitation of this research and particularly within the multi-component intervention of Chapter 6 (Study 3). Given that power increases as the number of participants increases and overall sample size is extremely influential on power, some of the

analyses may have lacked sufficient power to detect significant changes in outcomes (Thomas, Silverman, & Nelson, 2015).

8.2.5 Conceptual Framework

A strength of the overall thesis is the use of theory and conceptual models to underpin the design of the studies completed. This is the first study to employ the TEO (Beets et al., 2016) within the framework of the YPAPM (Welk, 1999). Resultantly, intervention components designed within Chapter 6 (Study 3) were sought to be appropriate for use and attainable within the school environment whilst also targeting factors that influence PA behaviours in children. For example, the ABs were implemented by class teachers and children participated alongside their peers. Both peers and teachers are reinforcing determinants of PA engagement within the YPAPM (Welk, 1999). The ABs also represent the expansion aspect of the TEO, which includes replacing time allocated for low active or sedentary activities with time allocated for more active activities (Beets et al., 2016). Expansion of PA opportunities embedded within a compulsory environment has been shown to positively impact youth to increase their PA but issues can arise with teachers willingness to reallocate time within schedules or timetables (Beets et al., 2016). This was therefore considered within the design of the ABs, and recommended length of implementation was five minutes to ensure minimal disruption was caused and teachers were also given the flexibility to implement ABs for less than five minutes if they felt this was more appropriate. The pragmatic nature of the theoretical components of the TEO strongly influenced the design of the intervention components within AS:Sk. Components were designed with a focus on implementation being based on practicalities within the

school setting with less focus on behavioural theoretical considerations. However, this approach is questionable given that the intervention was only successful at positively impacting ST and not MVPA. Conclusions cannot be made regarding the usefulness of the YPAPM as a framework for designing school-based PA interventions based solely on the PA outcomes of the AS:Sk multi-component intervention. Rather, it could be argued that a focus on practicality within the school environment lead to negligence surrounding intra- or inter-personal behavioural theories, despite their inclusion within the socio-ecological framework and also the YPAPM. While the YPAPM is not a theory in itself, it is a model which is built upon theory such as Social Cognitive Theory and includes predisposing factors such as competence and self-efficacy (Welk, 1999). Furthermore, the YPAPM demonstrates robust findings in previous research, supporting its utility for studying the psychosocial correlates and mediators of PA in both overweight and normal weight children (Chen, Welk, & Joens-Matre, 2014).

8.3 Recommendations

As a result of the findings presented from this programme of research, various recommendations for future work are proposed. These are separated into recommendations for research and practice.

8.3.1 Recommendations for practice

- All schools are different in the way they work day-to-day. School-based PA interventions should provide schools with strategies which are flexible and adaptable to implement in a way and at a time which best suits their individual needs.

- Whole-school (all age groups) approaches to PA promotion in schools are advocated, particularly to reduce competition for space.
- Due to the limited space readily available in schools, classroom-based activity should be encouraged for ease of implementation. However, this approach is limited by the impact which it can have on MVPA levels, and should therefore compliment other PA opportunities throughout the school day and week such as outdoor PA breaks and PE.
- Teachers who have engaged in school-based PA have reported positive effects in relation to classroom behaviour and children's academic performance. Schools should be made aware of these reports to encourage future participation in school-based PA.
- Creative strategies are needed for helping more older aged primary school children to independently engage in PA during recess.
- Multi-component school-based interventions should pay increased attention to the after-school period, as home-based activities may not be sufficient for positively impacting out of school PA levels.

8.3.2 Recommendations for future research

- Future research is needed to establish school-based strategies that are effective at increasing school-day MVPA levels and which have a limited or no financial cost to either the project or schools.
- Where possible, PA research that utilises accelerometers should use raw acceleration data to aid comparison between studies. Wrist-worn, 24-hour protocols are also recommended to optimise compliance.

- Future research should make efforts to gain ethical approvals for opt-out consent while maintaining compliance to the General Data Protection Regulation (GDPR). Gaining support for this from head teachers who regularly use opt-out with parents and carers provides added support to ethics applications.
- Further process evaluation of multi-component school-based PA interventions is warranted. Additionally, strategies are required for the recording of implementation frequency which are not reliant upon teacher logs or daily researcher visits. Potentially, rapport could be built between the researcher and an interested member of school staff or a designated school PA 'champion'. These staff members may have increased time in comparison to class teachers or a specific interest in PA and would subsequently be reliable for recording implementation frequency.
- Future research should make efforts to collect qualitative data from teachers and children to understand perceived feasibility and acceptability of PA strategies. The triangulation of data, utilising qualitative data alongside quantitative data, can enhance understanding of intervention implementation and efficacy.
- Up-scaling of a modified version of the AS:Sk multi-component intervention or similar is necessary. For example, focusing on the implementation of school-based PA strategies which are implemented by existing staff structures and have a low or no financial cost with a longer follow-up period (e.g. 12 months or longer).

8.4 Conclusions

The overall aim of this thesis was to explore intervention approaches to promoting primary school-based PA in a high deprivation community. Primarily, children attending the participating schools within areas of high deprivation, were not sufficiently active to benefit health and school-based PA strategies were justified. Furthermore, these results justified the selection of the high deprivation target area of the study, although this factor did not influence the subsequent intervention approaches which were designed and explored. Positive effects were observed on MVPA levels during the single-component intervention phase, however these were not translated into the outcomes of the multi-component clustered RCT. Positive effects of the multi-component intervention were however evident on school-day ST. The complexity of implementation in a real-world setting was emphasised. It is likely that implementation differed between intervention schools and had an effect on measured change in the outcomes. The school-based strategies explored indicated that it is paramount to have flexibility and adaptability to suit the individual needs of each school. The major barriers to participation were sufficient time and space which means that classroom-based activity is advantageous for teachers. Children consistently reported enjoyment of school-based PA and its positive effect on classroom behaviour was reported by both teachers and children alike. Up-scaling of a modified version of the AS:Sk multi-component intervention or similar is necessary to discover whether the type of school-based PA strategies used (implementation by existing school staff and no/limited financial cost) are sustainable for schools in the long-term.

References

- Abbott, R. A., Straker, L. M., & Mathiassen, S. E. (2013). Patterning of children's sedentary time at and away from school. *Obesity (Silver Spring)*, 21(1), E131-133. doi:10.1002/oby.20127
- Ahn, S., & Fedewa, A. L. (2011). A Meta-analysis of the Relationship Between Children's Physical Activity and Mental Health. *Journal of Pediatric Psychology*, 36(4), 385-397. doi:10.1093/jpepsy/jsq107
- Aires, L., Silva, P., Silva, G., Santos, M. P., Ribeiro, J. C., & Mota, J. (2010). Intensity of physical activity, cardiorespiratory fitness, and body mass index in youth. *J Phys Act Health*, 7(1), 54-59.
- Álvarez-Bueno, C., Pesce, C., Cervero-Redondo, I., Sánchez-López, M., Garrido-Miguel, M., & Martínez-Vizcaíno, V. (2017). Academic Achievement and Physical Activity: A Meta-analysis. *Pediatrics*. doi:10.1542/peds.2017-1498
- Anderman, C., Cheadle, A., Curry, S., Diehr, P., Shultz, L., & Wagner, E. (1995). Selection Bias Related To Parental Consent in School-Based Survey Research. *Evaluation Review*, 19(6), 663-674. doi:10.1177/0193841X9501900604
- Andersen, L. B., Riddoch, C., Kriemler, S., & Hills, A. P. (2011). Physical activity and cardiovascular risk factors in children. *Br J Sports Med*, 45(11), 871-876. doi:10.1136/bjsports-2011-090333
- Audrey, S., Bell, S., Hughes, R., & Campbell, R. (2013). Adolescent perspectives on wearing accelerometers to measure physical activity in population-based trials. *Eur J Public Health*, 23(3), 475-480. doi:10.1093/eurpub/cks081
- Australian Government, D. o. H. (2017). *Australia's Physical Activity & Sedentary Behaviour Guidelines for Children (5-12 years)*. Canberra, Australia.

- Bacil, E. D., Mazzardo Junior, O., Rech, C. R., Legnani, R. F., & de Campos, W. (2015). Physical activity and biological maturation: a systematic review. *Rev Paul Pediatr*, 33(1), 114-121. doi:10.1016/j.rpped.2014.11.003
- Bandura, A. (1996). Health promotion from the perspective of social cognitive theory. *Psychology & Health*, 13(4).
- Baquet, G., Ridgers, N. D., Blaes, A., Aucouturier, J., Van Praagh, E., & Berthoin, S. (2014). Objectively assessed recess physical activity in girls and boys from high and low socioeconomic backgrounds. *BMC public health*, 14, 192. doi:10.1186/1471-2458-14-192
- Barnett, L. M., van Beurden, E., Morgan, P. J., Brooks, L. O., & Beard, J. R. (2009). Childhood motor skill proficiency as a predictor of adolescent physical activity. *J Adolesc Health*, 44(3), 252-259. doi:10.1016/j.jadohealth.2008.07.004
- Bauman, A., Phongsavan, P., Schoeppe, S., & Owen, N. (2006). Physical activity measurement--a primer for health promotion. *Promot Educ*, 13(2), 92-103.
- Bauman, A. E., Reis, R. S., Sallis, J. F., Wells, J. C., Loos, R. J. F., & Martin, B. W. (2012). Correlates of physical activity: why are some people physically active and others not? *Lancet (London, England)*, 380(9838), 258. doi:10.1016/S0140-6736(12)60735-1
- Bauman, A. E., Sallis, J. F., Dzewaltowski, D. A., & Owen, N. (2002). Toward a better understanding of the influences on physical activity: the role of determinants, correlates, causal variables, mediators, moderators, and confounders. *Am J Prev Med*, 23(2 Suppl), 5-14.
- Beets, M. W., Okely, A., Weaver, R. G., Webster, C., Lubans, D., Brusseau, T., . . . Cliff, D. P. (2016). The theory of expanded, extended, and enhanced opportunities

- for youth physical activity promotion. *International Journal of Behavioral Nutrition and Physical Activity*, 13(1), 120. doi:10.1186/s12966-016-0442-2
- Beighle, A., & Moore, M. (2012). Physical Activity Before and After School. *Journal of Physical Education, Recreation & Dance*, 83(6), 25-28. doi:10.1080/07303084.2012.10598792
- Beltran-Carrillo, V. J., Ferriz, R., Brown, D. H. K., & Gonzalez-Cutre, D. (2017). Qualitative evaluation of a school intervention for the promotion of physical activity: Learning from the perspective of the target population. *European Journal of Human Movement*, 38, 69-92.
- Berliner, D. C. (2002). Educational Research: The Hardest Science of All. *Educational Researcher*, 31(8), 18-20.
- Best, K., Ball, K., Zarnowiecki, D., Stanley, R., & Dollman, J. (2017). In Search of Consistent Predictors of Children's Physical Activity. *Int J Environ Res Public Health*, 14(10). doi:10.3390/ijerph14101258
- Beyler, N., Bleeker, M., James-Burdumy, S., Fortson, J., & Benjamin, M. (2014). The impact of Playworks on students' physical activity during recess: Findings from a randomized controlled trial. *Preventive Medicine*, 69, S20-S26. doi:<https://doi.org/10.1016/j.ypmed.2014.10.011>
- Biddle, S. J. H., García Bengoechea, E., & Wiesner, G. (2017). Sedentary behaviour and adiposity in youth: a systematic review of reviews and analysis of causality. *International Journal of Behavioral Nutrition and Physical Activity*, 14(1), 43. doi:10.1186/s12966-017-0497-8
- Blom-Hoffman, J., Leff, S. S., Franko, D. L., Weinstein, E., Beakley, K., & Power, T. J. (2009). Consent Procedures and Participation Rates in School-Based

- Intervention and Prevention Research: Using a Multi-Component, Partnership-Based Approach to Recruit Participants. *School mental health*, 1(1), 3-15. doi:10.1007/s12310-008-9000-7
- Blom, A., Tammelin, T., Laine, K., & Tolonen, H. (2017). Bright spots, physical activity investments that work: the Finnish Schools on the Move programme. *British Journal of Sports Medicine*. doi:10.1136/bjsports-2017-097711
- Boddy, L. M., Murphy, M. H., Cunningham, C., Breslin, G., Foweather, L., Gobbi, R., . . . Stratton, G. (2014). Physical activity, cardiorespiratory fitness, and clustered cardiometabolic risk in 10- to 12-year-old school children: The REACH Y6 study. *American Journal of Human Biology*, 26(4), 446-451. doi:10.1002/ajhb.22537
- Borraccino, A., Lemma, P., Iannotti, R. J., Zambon, A., Dalmasso, P., Lazzeri, G., . . . Cavallo, F. (2009). Socioeconomic effects on meeting physical activity guidelines: comparisons among 32 countries. *Med Sci Sports Exerc*, 41(4), 749-756. doi:10.1249/MSS.0b013e3181917722
- Bradley, R. H., & Corwyn, R. F. (2002). Socioeconomic status and child development. *Annu Rev Psychol*, 53, 371-399. doi:10.1146/annurev.psych.53.100901.135233
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77-101. doi:10.1191/1478088706qp063oa
- Braun, V., & Clarke, V. (2013). *Successful Qualitative Research, a practical guide for beginners*. London: SAGE Publications.
- Brazendale, K., Chandler, J. L., Beets, M. W., Weaver, R. G., Beighle, A., Huberty, J. L., & Moore, J. B. (2015). Maximizing children's physical activity using the LET US Play principles. *Prev Med*, 76, 14-19. doi:10.1016/j.ypmed.2015.03.012

- Brener, N. D., Pejavara, A., Barrios, L. C., Crossett, L., Lee, S. M., McKenna, M., . . . Wechsler, H. (2006). Applying the School Health Index to a nationally representative sample of schools. *J Sch Health, 76*(2), 57-66. doi:10.1111/j.1746-1561.2006.00069.x
- Brusseau, T. A., Hannon, J., & Burns, R. (2016). The Effect of a Comprehensive School Physical Activity Program on Physical Activity and Health-Related Fitness in Children From Low-Income Families. *J Phys Act Health, 13*(8), 888-894. doi:10.1123/jpah.2016-0028
- Bulger, S. M., Mohr, D. J., Carson, L. M., & Wiegand, R. L. (2001). Infusing Health-Related Physical Fitness in Physical Education Teacher Education. *Quest, 53*(4), 403-417. doi:10.1080/00336297.2001.10491755
- Burges Watson, D., Adams, J., Azevedo, L. B., & Haighton, C. (2016). Promoting physical activity with a school-based dance mat exergaming intervention: qualitative findings from a natural experiment. *BMC public health, 16*(1), 609. doi:10.1186/s12889-016-3308-2
- Bürgi, R., Tomatis, L., Murer, K., & de Bruin, E. D. (2016). Spatial physical activity patterns among primary school children living in neighbourhoods of varying socioeconomic status: a cross-sectional study using accelerometry and Global Positioning System. *BMC public health, 16*(1), 282. doi:10.1186/s12889-016-2954-8
- Burns, R. D., Brusseau, T. A., & Hannon, J. C. (2015). Effect of a Comprehensive School Physical Activity Program on School Day Step Counts in Children. *J Phys Act Health, 12*(12), 1536-1542. doi:10.1123/jpah.2014-0578

- Burns, R. D., Fu, Y., & Podlog, L. W. (2017). School-based physical activity interventions and physical activity enjoyment: A meta-analysis. *Prev Med*, 103, 84-90. doi:10.1016/j.ypmed.2017.08.011
- Butte, N. F., Ekelund, U., & Westerterp, K. R. (2012). Assessing physical activity using wearable monitors: measures of physical activity. *Med Sci Sports Exerc*, 44(1 Suppl 1), S5-12. doi:10.1249/MSS.0b013e3182399c0e
- Cain, K. L., Sallis, J. F., Conway, T. L., Van Dyck, D., & Calhoun, L. (2013). Using accelerometers in youth physical activity studies: a review of methods. *J Phys Act Health*, 10(3), 437-450.
- Campbell, M. K., Piaggio, G., Elbourne, D. R., & Altman, D. G. (2012). Consort 2010 statement: extension to cluster randomised trials. *BMJ*, 345, e5661. doi:10.1136/bmj.e5661
- Campbell, R., Rawlins, E., Wells, S., Kipping, R. R., Chittleborough, C. R., Peters, T. J., . . . Jago, R. (2015). Intervention fidelity in a school-based diet and physical activity intervention in the UK: Active for Life Year 5. *Int J Behav Nutr Phys Act*, 12, 141. doi:10.1186/s12966-015-0300-7
- Carlson, J. A., Engelberg, J. K., Cain, K. L., Conway, T. L., Geremia, C., Bonilla, E., . . . Sallis, J. F. (2017). Contextual factors related to implementation of classroom physical activity breaks. *Transl Behav Med*, 7(3), 581-592. doi:10.1007/s13142-017-0509-x
- Carlson, J. A., Engelberg, J. K., Cain, K. L., Conway, T. L., Mignano, A. M., Bonilla, E. A., . . . Sallis, J. F. (2015). Implementing classroom physical activity breaks: Associations with student physical activity and classroom behavior. *Prev Med*, 81, 67-72. doi:10.1016/j.ypmed.2015.08.006

- Carson, R. L., Castelli, D. M., & Beighle, A., & Erwin, H. (2014). School-based physical activity promotion: a conceptual framework for research and practice. *Child Obes*, 10(2), 100-106. doi:10.1089/chi.2013.0134
- Carson, V., Hunter, S., Kuzik, N., Gray, C. E., Poitras, V. J., Chaput, J. P., . . . Connor Gorber, S. (2016). Systematic review of sedentary behaviour and health indicators in school-aged children and youth: an update. *Appl Physiol Nutr Metab*, 41. doi:10.1139/apnm-2015-0630
- Carson, V., Hunter, S., Kuzik, N., Wiebe, S. A., Spence, J. C., Friedman, A., . . . Hinkley, T. (2016). Systematic review of physical activity and cognitive development in early childhood. *J Sci Med Sport*, 19(7), 573-578. doi:10.1016/j.jsams.2015.07.011
- Carson, V., Ridgers, N. D., Howard, B. J., Winkler, E. A. H., Healy, G. N., Owen, N., . . . Salmon, J. (2013). Light-Intensity Physical Activity and Cardiometabolic Biomarkers in US Adolescents. *PLoS One*, 8(8), e71417. doi:10.1371/journal.pone.0071417
- Carson, V., Tremblay, M. S., Chaput, J. P., & Chastin, S. F. (2016). Associations between sleep duration, sedentary time, physical activity, and health indicators among Canadian children and youth using compositional analyses. *Appl Physiol Nutr Metab*, 41(6 Suppl 3), S294-302. doi:10.1139/apnm-2016-0026
- Carter, N., Bryant-Lukosius, D., DiCenso, A., Blythe, J., & Neville, A. J. (2014). The use of triangulation in qualitative research. *Oncol Nurs Forum*, 41(5), 545-547. doi:10.1188/14.onf.545-547

- Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health Reports*, 100(2), 126-131.
- Cathain, A., Thomas, K. J., Drabble, S. J., Rudolph, A., & Hewison, J. (2013). What can qualitative research do for randomised controlled trials? A systematic mapping review. *BMJ Open*, 3(6).
- Centers for Disease Control and Prevention. (2013). *Make a Difference at Your School!* Washington D.C. Retrieved from <https://www.cdc.gov/healthyyouth/keystrategies/pdf/make-a-difference.pdf>.
- Chen, S., & Gu, X. (2017). Toward Active Living: Comprehensive School Physical Activity Program Research and Implications. *Quest*, 1-22. doi:10.1080/00336297.2017.1365002
- Chen, S., Welk, G. J., & Joens-Matre, R. R. (2014). Testing the youth physical activity promotion model: Fatness and fitness as enabling factors. *Meas Phys Educ Exerc Sci*, 18(4), 227-241.
- Chesham, R. A., Booth, J. N., Sweeney, E. L., Ryde, G. C., Gorely, T., Brooks, N. E., & Moran, C. N. (2018). The Daily Mile makes primary school children more active, less sedentary and improves their fitness and body composition: a quasi-experimental pilot study. *BMC Med*, 16(1), 64. doi:10.1186/s12916-018-1049-z
- Chief Medical Officer Department of Health. (2011). *Start Active, Stay Active: A report on physical activity from the four home countries'. Department of Health.* London.

- Chillon, P., Ortega, F. B., Ruiz, J. R., Veidebaum, T., Oja, L., Maestu, J., & Sjostrom, M. (2010). Active commuting to school in children and adolescents: an opportunity to increase physical activity and fitness. *Scand J Public Health*, 38(8), 873-879. doi:10.1177/1403494810384427
- Chin, J. J., & Ludwig, D. (2013). Increasing children's physical activity during school recess periods. *Am J Public Health*, 103(7), 1229-1234. doi:10.2105/ajph.2012.301132
- Christian, D., Todd, C., Davies, H., Rance, J., Stratton, G., Rapport, F., & Brophy, S. (2015). Community led active schools programme (CLASP) exploring the implementation of health interventions in primary schools: headteachers' perspectives. *BMC public health*, 15(1), 238. doi:10.1186/s12889-015-1557-0
- Claxton, D., & Wells, G. M. (2009). The effect of physical activity homework on physical activity among college students. *J Phys Act Health*, 6(2), 203-210.
- Cline, A., Schafer-Kalkhoff, T., Strickland, E., & Hamann, T. (2005). Recruitment strategies for the Princeton (Ohio) City School District epidemiological study. *J Sch Health*, 75(5), 189-191.
- Cohen, K. E., Morgan, P. J., Plotnikoff, R. C., Callister, R., & Lubans, D. R. (2015). Physical activity and skills intervention: SCORES cluster randomized controlled trial. *Med Sci Sports Exerc*, 47(4), 765-774. doi:10.1249/mss.0000000000000452
- Collins, S. (2015). *Seven Wards: A focus on Skelmersdale*. Public Health and Wellbeing Service, County Council Lancashire. Retrieved from <http://www.westlancashireccg.nhs.uk/wp-content/uploads/Skelmersdale.pdf>.

- Committee on Physical Activity and Physical Education in the School Environment, Food and Nutrition Board, & Institute of Medicine. (2013). *Educating the student body: Taking physical activity and physical education to school*. Washington, DC: The National Academies Press.
- Coombs, N., Shelton, N., Rowlands, A., & Stamatakis, E. (2013). Children's and adolescents' sedentary behaviour in relation to socioeconomic position. *J Epidemiol Community Health*, 67(10), 868-874. doi:10.1136/jech-2013-202609
- Cooper, A. R., Goodman, A., Page, A. S., Sherar, L. B., Esliger, D. W., van Sluijs, E. M., . . . Ekelund, U. (2015). Objectively measured physical activity and sedentary time in youth: the International children's accelerometry database (ICAD). *Int J Behav Nutr Phys Act*, 12, 113. doi:10.1186/s12966-015-0274-5
- Cope, D. G. (2014). Methods and Meanings: Credibility and Trustworthiness of Qualitative Research. *Oncology Nursing Forum*, 41(1), 89-91. doi:10.1188/14.ONF.89-91
- Copley, V. R., & Bray, C. (2017). *National Child Measurement Programme. Changes in children's body mass index between 2006/07 and 2015/16. Detailed Report*. London, Public Health England. Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/646271/national_child_measurement_programme_changes_in_childrens_BMI_detailed_report.pdf.
- Craig, P., Dieppe, P., Macintyre, S., Michie, S., Nazareth, I., & Petticrew, M. (2008). Developing and evaluating complex interventions: the new Medical Research Council guidance. *BMJ*, 337. doi:10.1136/bmj.a1655

- Craike, M., Wiesner, G., Hilland, T. A., & Bengoechea, E. G. (2018). Interventions to improve physical activity among socioeconomically disadvantaged groups: an umbrella review. *International Journal of Behavioral Nutrition and Physical Activity*, 15(1), 43. doi:10.1186/s12966-018-0676-2
- Cumming, S. P., Sherar, L. B., Esliger, D. W., Riddoch, C. J., & Malina, R. M. (2014). Concurrent and prospective associations among biological maturation, and physical activity at 11 and 13 years of age. *Scand J Med Sci Sports*, 24(1), e20-28. doi:10.1111/sms.12103
- Cumming, S. P., Standage, M., Gillison, F., & Malina, R. M. (2008). Sex differences in exercise behavior during adolescence: is biological maturation a confounding factor? *J Adolesc Health*, 42(5), 480-485. doi:10.1016/j.jadohealth.2007.10.005
- Dale, D., Corbin, C. B., & Dale, K. S. (2000). Restricting opportunities to be active during school time: do children compensate by increasing physical activity levels after school? *Res Q Exerc Sport*, 71(3), 240-248. doi:10.1080/02701367.2000.10608904
- Daly-Smith, A. J., Zwolinsky, S., McKenna, J., Tomporowski, P. D., Defeyter, M. A., & Manley, A. (2018). Systematic review of acute physically active learning and classroom movement breaks on children's physical activity, cognition, academic performance and classroom behaviour: understanding critical design features. *BMJ Open Sport Exerc Med*, 4(1), e000341. doi:10.1136/bmjsem-2018-000341
- Davison, K. K., & Lawson, C. T. (2006). Do attributes in the physical environment influence children's physical activity? A review of the literature. *The*

international journal of behavioral nutrition and physical activity, 3, 19-19.

doi:10.1186/1479-5868-3-19

Department for Education. (2015). *The PE and sport premium: an investigation in primary schools*. London Retrieved from [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/489477/DFE-RR489 PE and sport premium an investigation in primary schools - final report.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/489477/DFE-RR489_PE_and_sport_premium_an_investigation_in_primary_schools_-_final_report.pdf).

Ding, D., Sallis, J. F., Kerr, J., Lee, S., & Rosenberg, D. E. (2011). Neighborhood Environment and Physical Activity Among Youth: A Review. *American Journal of Preventive Medicine*, 41(4), 442-455. doi:<https://doi.org/10.1016/j.amepre.2011.06.036>

Dobbins, M., De Corby, K., Robeson, P., Husson, H., & Tirilis, D. (2009). School-based physical activity programs for promoting physical activity and fitness in children and adolescents aged 6-18. *Cochrane Database Syst Rev*(1), Cd007651. doi:10.1002/14651858.cd007651

Drenowatz, C., Eisenmann, J. C., Pfeiffer, K. A., Welk, G., Heelan, K., Gentile, D., & Walsh, D. (2010). Influence of socio-economic status on habitual physical activity and sedentary behavior in 8- to 11-year old children. *BMC public health*, 10, 214. doi:10.1186/1471-2458-10-214

Dumith, S. C., Gigante, D. P., Domingues, M. R., & Kohl, H. W. (2011). Physical activity change during adolescence: a systematic review and a pooled analysis. *Int J Epidemiol*, 40. doi:10.1093/ije/dyq272

- Dumuid, D., Stanford, T. E., Pedišić, Ž., Maher, C., Lewis, L. K., Martín-Fernández, J.-A., . . . Olds, T. (2018). Adiposity and the isothermal substitution of physical activity, sedentary time and sleep among school-aged children: a compositional data analysis approach. *BMC public health*, 18(1), 311. doi:10.1186/s12889-018-5207-1
- Durlak, J. A., & DuPre, E. P. (2008). Implementation matters: a review of research on the influence of implementation on program outcomes and the factors affecting implementation. *Am J Community Psychol*, 41. doi:10.1007/s10464-008-9165-0
- Dyrstad, S. M., Kvalø, S. E., Alstveit, M., & Skage, I. (2018). Physically active academic lessons: acceptance, barriers and facilitators for implementation. *BMC public health*, 18(1), 322. doi:10.1186/s12889-018-5205-3
- Eather, N., Morgan, P. J., & Lubans, D. R. (2013). Social support from teachers mediates physical activity behavior change in children participating in the Fit-4-Fun intervention. *International Journal of Behavioral Nutrition and Physical Activity*, 10(1), 68. doi:10.1186/1479-5868-10-68
- Ekelund, U., Luan, J., Sherar, L. B., Esliger, D. W., Griew, P., & Cooper, A. (2012). Moderate to vigorous physical activity and sedentary time and cardiometabolic risk factors in children and adolescents. *JAMA*, 307(7), 704-712. doi:10.1001/jama.2012.156
- Ekelund, U., Sjostrom, M., Yngve, A., Poortvliet, E., Nilsson, A., Froberg, K., . . . Westerterp, K. (2001). Physical activity assessed by activity monitor and doubly labeled water in children. *Med Sci Sports Exerc*, 33(2), 275-281.

- Elder, J. P., Lytle, L., Sallis, J. F., Young, D. R., Steckler, A., Simons-Morton, D., . . . Ribisl, K. (2007). A description of the social-ecological framework used in the trial of activity for adolescent girls (TAAG). *Health Education Research*, 22(2), 155-165. doi:10.1093/her/cyl059
- Elhakeem, A., Cooper, R., Bann, D., & Hardy, R. (2015). Childhood socioeconomic position and adult leisure-time physical activity: a systematic review. *International Journal of Behavioral Nutrition and Physical Activity*, 12(1), 92. doi:10.1186/s12966-015-0250-0
- Elliot, E., Erwin, H., Hall, T., & Heidorn, B. (2013). Comprehensive School Physical Activity Programs: Helping All Students Achieve 60 Minutes of Physical Activity Each Day. *Journal of Physical Education, Recreation & Dance*, 84(9), 9-15. doi:10.1080/07303084.2013.838105
- Erwin, H., Beighle, A., Carson, R. L., & Castelli, D. M. (2013). Comprehensive School-Based Physical Activity Promotion: A Review. *Quest*, 65(4), 412-428. doi:10.1080/00336297.2013.791872
- Erwin, H. E., Ickes, M., Ahn, S., & Fedewa, A. (2014). Impact of Recess Interventions on Children's Physical Activity—A Meta-Analysis. *American Journal of Health Promotion*, 28(3), 159-167. doi:10.4278/ajhp.120926-LIT-470
- Eyre, E. L., Duncan, M. J., Birch, S. L., Cox, V., & Blackett, M. (2015). Physical activity patterns of ethnic children from low socio-economic environments within the UK. *J Sports Sci*, 33(3), 232-242. doi:10.1080/02640414.2014.934706
- Eyre, E. L., Duncan, M. J., Birch, S. L., & Cox, V. M. (2014). Low socio-economic environmental determinants of children's physical activity in Coventry, UK: A

- Qualitative study in parents. *Prev Med Rep*, 1, 32-42.
doi:10.1016/j.pmedr.2014.09.002
- Fairclough, S. J., Beighle, A., Erwin, H., & Ridgers, N. D. (2012). School day segmented physical activity patterns of high and low active children. *BMC public health*, 12(1), 406. doi:10.1186/1471-2458-12-406
- Fairclough, S. J., Butcher, Z. H., & Stratton, G. (2008). Primary school children's health-enhancing physical activity patterns: the school as a significant environment? *Education 3-13*, 36(4), 371-381. doi:10.1080/03004270801959676
- Fairclough, S. J., Dumuid, D., Taylor, S., Curry, W., McGrane, B., Stratton, G., . . . Olds, T. (2017). Fitness, fatness and the reallocation of time between children's daily movement behaviours: an analysis of compositional data. *International Journal of Behavioral Nutrition and Physical Activity*, 14(1), 64. doi:10.1186/s12966-017-0521-z
- Fairclough, S. J., Hackett, A. F., Davies, I. G., Gobbi, R., Mackintosh, K. A., Warburton, G. L., . . . Boddy, L. M. (2013). Promoting healthy weight in primary school children through physical activity and nutrition education: a pragmatic evaluation of the CHANGE! randomised intervention study. *BMC public health*, 13(1), 626. doi:10.1186/1471-2458-13-626
- Fairclough, S. J., McGrane, B., Sanders, G., Taylor, S., Owen, M., & Curry, W. (2016). A non-equivalent group pilot trial of a school-based physical activity and fitness intervention for 10-11 year old english children: born to move. *BMC public health*, 16(1), 861. doi:10.1186/s12889-016-3550-7
- Fairclough, S. J., Noonan, R., Rowlands, A. V., Van Hees, V., Knowles, Z., & Boddy, L. M. (2016). Wear Compliance and Activity in Children Wearing Wrist- and Hip-

- Mounted Accelerometers. *Med Sci Sports Exerc*, 48(2), 245-253.
doi:10.1249/mss.0000000000000771
- Fairclough, S. J., & Ridgers, N. D. (2010). Relationships between maturity status, physical activity, and physical self-perceptions in primary school children. *Journal of Sports Sciences*, 28(1), 1-9. doi:10.1080/02640410903334780
- Fairclough, S. J., Ridgers, N. D., & Welk, G. (2012). Correlates of children's moderate and vigorous physical activity during weekdays and weekends. *J Phys Act Health*, 9(1), 129-137.
- Faulkner, G., Mitra, R., Buliung, R., Fusco, C., & Stone, M. (2015). Children's outdoor playtime, physical activity, and parental perceptions of the neighbourhood environment. *International Journal of Play*, 4(1), 84-97.
doi:10.1080/21594937.2015.1017303
- Fischer, C., Yildirim, M., Salmon, J., & Chinapaw, M. J. (2012). Comparing different accelerometer cut-points for sedentary time in children. *Pediatr Exerc Sci*, 24(2), 220-228.
- Fitzgerald, A., Fitzgerald, N., & Aherne, C. (2012). Do peers matter? A review of peer and/or friends' influence on physical activity among American adolescents. *Journal of Adolescence*, 35(4), 941-958.
doi:<http://dx.doi.org/10.1016/j.adolescence.2012.01.002>
- Fletcher, A. C., & Hunter, A. G. (2004). Strategies for Obtaining Parental Consent to Participate in Research. *Family Relations*, 52(3), 216-221. doi:10.1111/j.1741-3729.2003.00216.x
- Fox, K. R., Cooper, A., & McKenna, J. (2004). The School and Promotion of Children's Health-Enhancing Physical Activity: Perspectives from the United Kingdom.

Journal of Teaching in Physical Education, 23(4), 338-358.

doi:10.1123/jtpe.23.4.338

Franzini, L., Elliott, M. N., Cuccaro, P., Schuster, M., Gilliland, M. J., Grunbaum, J. A., . .

. Tortolero, S. R. (2009). Influences of Physical and Social Neighborhood Environments on Children's Physical Activity and Obesity. *American Journal of Public Health*, 99(2), 271-278. doi:10.2105/AJPH.2007.128702

Freedson, P., Bowles, H. R., Troiano, R., & Haskell, W. (2012). Assessment of physical activity using wearable monitors: recommendations for monitor calibration and use in the field. *Med Sci Sports Exerc*, 44(1 Suppl 1), S1-4. doi:10.1249/MSS.0b013e3182399b7e

Gába, A., Dygrýn, J., Mitáš, J., Jakubec, L., & Frömel, K. (2016). Effect of Accelerometer Cut-Off Points on the Recommended Level of Physical Activity for Obesity Prevention in Children. *PLoS One*, 11(10), e0164282. doi:10.1371/journal.pone.0164282

Gabhainn, S. N., & Kelleher, C. (2002). The sensitivity of the draw and write technique. *Health Education*, 102(2), 68-75. doi:10.1108/09654280210418992

Gebremariam, M. K., Altenburg, T. M., Lakerveld, J., Andersen, L. F., Stronks, K., Chinapaw, M. J., & Lien, N. (2015). Associations between socioeconomic position and correlates of sedentary behaviour among youth: a systematic review. *Obes Rev*, 16(11), 988-1000. doi:10.1111/obr.12314

Gebremariam, M. K., H Bergh, I., F Andersen, L., Ommundsen, Y., Bjelland, M., & Lien, N. (2012). Stability and change in potential correlates of physical activity and association with pubertal status among Norwegian children in the transition

- between childhood and adolescence. *International Journal of Behavioral Nutrition and Physical Activity*, 9(1), 56. doi:10.1186/1479-5868-9-56
- Gibson, J. E. (2012). Interviews and Focus Groups With Children: Methods That Match Children's Developing Competencies. *Journal of Family Theory & Review*, 4(2), 148-159. doi:doi:10.1111/j.1756-2589.2012.00119.x
- Gomes, T. N., Katzmarzyk, P. T., Hedeker, D., Fogelholm, M., Standage, M., Onywera, V., . . . Maia, J. (2017). Correlates of compliance with recommended levels of physical activity in children. *SCIENTIFIC REPORTS*, 7, 1-11. doi:10.1038/s41598-017-16525-9
- Gorely, T., Morris, J. G., Musson, H., Brown, S., Nevill, A., & Nevill, M. E. (2011). Physical activity and body composition outcomes of the GreatFun2Run intervention at 20 month follow-up. *International Journal of Behavioral Nutrition and Physical Activity*, 8(1), 74. doi:10.1186/1479-5868-8-74
- Griffiths, L. J., Cortina-Borja, M., Sera, F., Pouliou, T., Geraci, M., Rich, C., . . . Dezateux, C. (2013). How active are our children? Findings from the Millennium Cohort Study. *BMJ Open*, 3(8).
- Grund, A., Dilba, B., Forberger, K., Krause, H., Siewers, M., Rieckert, H., & Müller, M. J. (2000). Relationships between physical activity, physical fitness, muscle strength and nutritional state in 5- to 11-year-old children. *European Journal of Applied Physiology*, 82(5), 425-438. doi:10.1007/s004210000197
- Haapala, H. L., Hirvensalo, M. H., Kulmala, J., Hakonen, H., Kankaanpää, A., Laine, K., . . . Tammelin, T. H. (2017). Changes in physical activity and sedentary time in the Finnish Schools on the Move program: a quasi-experimental study.

- Scandinavian journal of medicine & science in sports*, 27(11), 1442-1453.
doi:10.1111/sms.12790
- Hallal, P. C., Andersen, L. B., Bull, F. C., Guthold, R., Haskell, W., & Ekelund, U. (2012). Global physical activity levels: surveillance progress, pitfalls, and prospects. *Lancet*, 380(9838), 247-257. doi:10.1016/s0140-6736(12)60646-1
- Harrington, D. M., Davies, M. J., Bodicoat, D. H., Charles, J. M., Chudasama, Y. V., Gorely, T., . . . Edwardson, C. L. (2018). Effectiveness of the 'Girls Active' school-based physical activity programme: A cluster randomised controlled trial. *International Journal of Behavioral Nutrition and Physical Activity*, 15(1), 40. doi:10.1186/s12966-018-0664-6
- Harris, J., & White, V. (2013). *A Dictionary of Social Work and Social Care*. Oxford, United Kingdom: Oxford University Press.
- Hay, J., Maximova, K., Durksen, A., Carson, V., Rinaldi, R. L., Torrance, B., . . . McGavock, J. (2012). Physical activity intensity and cardiometabolic risk in youth. *Arch Pediatr Adolesc Med*, 166(11), 1022-1029. doi:10.1001/archpediatrics.2012.1028
- Health Council of the Netherlands. (2017). *Physical Activity Guidelines 2017*. The Hague.
- Hemming, K., Girling, A. J., Sitch, A. J., Marsh, J., & Lilford, R. J. (2011). Sample size calculations for cluster randomised controlled trials with a fixed number of clusters. *BMC Med Res Methodol*, 11, 102. doi:10.1186/1471-2288-11-102
- Hildebrand, M., Hansen, B. H., van Hees, V. T., & Ekelund, U. (2017). Evaluation of raw acceleration sedentary thresholds in children and adults. *Scand J Med Sci Sports*, 27(12), 1814-1823. doi:10.1111/sms.12795

- Hildebrand, M., Van Hees, V. T., Hansen, B. H., & Ekelund, U. L. F. (2014). Age Group Comparability of Raw Accelerometer Output from Wrist- and Hip-Worn Monitors. *Medicine & Science in Sports & Exercise*, 46(9), 1816-1824. doi:10.1249/MSS.0000000000000289
- Hills, A. P., Dengel, D. R., & Lubans, D. R. (2015). Supporting public health priorities: recommendations for physical education and physical activity promotion in schools. *Prog Cardiovasc Dis*, 57(4), 368-374. doi:10.1016/j.pcad.2014.09.010
- HM Government. (2016). *Childhood Obesity: A Plan for Action*. London. Retrieved from <https://www.gov.uk/government/publications/childhood-obesity-a-plan-for-action>.
- Hollmann, C. M., & McNamara, J. R. (1999). Considerations in the Use of Active and Passive Parental Consent Procedures. *The Journal of Psychology*, 133(2), 141-156. doi:10.1080/00223989909599729
- Howe, C. A., Freedson, P. S., Alhassan, S., Feldman, H. A., & Osganian, S. K. (2012). A recess intervention to promote moderate-to-vigorous physical activity. *Pediatr Obes*, 7(1), 82-88. doi:10.1111/j.2047-6310.2011.00007.x
- Howie, E. K., Newman-Norlund, R. D., & Pate, R. R. (2014). Smiles count but minutes matter: responses to classroom exercise breaks. *Am J Health Behav*, 38(5), 681-689. doi:10.5993/ajhb.38.5.5
- Huang, W. Y., Wong, S. H., He, G., & Salmon, J. O. (2016). Isotemporal Substitution Analysis for Sedentary Behavior and Body Mass Index. *Med Sci Sports Exerc*, 48(11), 2135-2141. doi:10.1249/mss.0000000000001002

- Huberty, J. L., Siahpush, M., Beighle, A., Fuhrmeister, E., Silva, P., & Welk, G. (2011). Ready for recess: a pilot study to increase physical activity in elementary school children. *J Sch Health*, 81(5), 251-257. doi:10.1111/j.1746-1561.2011.00591.x
- Hyndman, B. (2016). A Qualitative Investigation of Australian Youth Perceptions to Enhance School Physical Activity: The Environmental Perceptions Investigation of Children's Physical Activity (EPIC-PA) Study. *Journal of Physical Activity and Health*, 13(5), 543-550. doi:10.1123/jpah.2015-0165
- Hyndman, B., Benson, A., & Telford, A. (2016). Active Play: Exploring the Influences on Children's School Playground Activities. *American Journal of Play*, 8(3), 325.
- Ickes, M. J., Erwin, H., & Beighle, A. (2013). Systematic review of recess interventions to increase physical activity. *J Phys Act Health*, 10(6), 910-926.
- Jago, R., Edwards, M. J., Sebire, S. J., Cooper, A. R., Powell, J. E., Bird, E. L., . . . Blair, P. S. (2013). Bristol girls dance project (BGDP): protocol for a cluster randomised controlled trial of an after-school dance programme to increase physical activity among 11–12 year old girls. *BMC Public Health*, 13(1003). doi:10.1186/1471-2458-13-1003.
- Jago, R., Macdonald-Wallis, K., Thompson, J. L., Page, A. S., Brockman, R., & Fox, K. R. (2011). Better with a buddy: influence of best friends on children's physical activity. *Med Sci Sports Exerc*, 43(2), 259-265. doi:10.1249/MSS.0b013e3181edefaa
- Jago, R., Rawlins, E., Kipping, R. R., Wells, S., Chittleborough, C., Peters, T. J., . . . Campbell, R. (2015). Lessons learned from the AFLY5 RCT process evaluation: implications for the design of physical activity and nutrition interventions in schools. *BMC public health*, 15(1), 946. doi:10.1186/s12889-015-2293-1

- Jago, R., Solomon-Moore, E., Macdonald-Wallis, C., Sebire, S. J., Thompson, J. L., & Lawlor, D. A. (2017). Change in children's physical activity and sedentary time between Year 1 and Year 4 of primary school in the B-PROACT1V cohort. *International Journal of Behavioral Nutrition and Physical Activity*, 14(1), 33. doi:10.1186/s12966-017-0492-0
- Jago, R., Solomon-Moore, E., Toumpakari, Z., Lawlor, D. A., Thompson, J. L., & Sebire, S. J. (2018). Parents' perspectives of change in child physical activity & screen-viewing between Y1 (5-6) & Y4 (8-9) of primary school: implications for behaviour change. *BMC public health*, 18(1), 520. doi:10.1186/s12889-018-5445-2
- Janssen, I., & LeBlanc, A. G. (2010). Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity*, 7(1), 40. doi:10.1186/1479-5868-7-40
- Jason, L. A., Pokorny, S. B., & Katz, R. (2001). Passive versus active consent: A case study in school settings. *Journal of Community Psychology*, 29(1), 53-68. doi:10.1002/1520-6629(200101)29:1<53::AID-JCOP4>3.0.CO;2-6
- Ji, P. Y., Pokorny, S. B., & Jason, L. A. (2004). Factors influencing middle and high schools' active parental consent return rates. *Eval Rev*, 28(6), 578-591. doi:10.1177/0193841x04263917
- Jones, N. R., Jones, A., van Sluijs, E. M. F., Panter, J., Harrison, F., & Griffin, S. J. (2010). School environments and physical activity: The development and testing of an audit tool. *Health & Place*, 16(5), 776-783. doi:<https://doi.org/10.1016/j.healthplace.2010.04.002>

- Jones, R. A., Lubans, D. R., Morgan, P. J., Okely, A. D., Parletta, N., Wolfenden, L., . . . Waters, E. (2014). School-based obesity prevention interventions: practicalities and considerations. *Obes Res Clin Pract*, 8(5), e497-510. doi:10.1016/j.orcp.2013.10.004
- Katzmarzyk, P. T., Denstel, K. N., Beals, K., Bolling, C., Wright, C., Crouter, S. E., . . . Sisson, S. B. (2016). Results from the United States of America's 2016 Report Card on Physical Activity for Children and Youth. *Journal of physical activity & health*, 13(11 Suppl 2), S307-S313. doi:10.1123/jpah.2016-0321
- Kellou, N., Sandalinas, F., Copin, N., & Simon, C. (2014). Prevention of unhealthy weight in children by promoting physical activity using a socio-ecological approach: what can we learn from intervention studies? *Diabetes Metab*, 40(4), 258-271. doi:10.1016/j.diabet.2014.01.002
- Kipping, R. R., Howe, L. D., Jago, R., Campbell, R., Wells, S., Chittleborough, C. R., . . . Lawlor, D. A. (2014). Effect of intervention aimed at increasing physical activity, reducing sedentary behaviour, and increasing fruit and vegetable consumption in children: active for Life Year 5 (AFLY5) school based cluster randomised controlled trial. *BMJ*, 348, g3256. doi:10.1136/bmj.g3256
- Kirby, J., Levin, K. A., & Inchley, J. (2013). Socio-environmental influences on physical activity among young people: a qualitative study. *Health Educ Res*, 28(6), 954-969. doi:10.1093/her/cyt085
- Klinker, C. D., Schipperijn, J., Christian, H., Kerr, J., Ersbøll, A. K., & Troelsen, J. (2014). Using accelerometers and global positioning system devices to assess gender and age differences in children's school, transport, leisure and home based

- physical activity. *International Journal of Behavioral Nutrition and Physical Activity*, 11(1), 8. doi:10.1186/1479-5868-11-8
- Kneeshaw-Price, S. H., Saelens, B. E., Sallis, J. F., Frank, L. D., Grembowski, D. E., Hannon, P. A., . . . Chan, K. C. G. (2015). Neighborhood Crime-Related Safety and Its Relation to Children's Physical Activity. *Journal of Urban Health : Bulletin of the New York Academy of Medicine*, 92(3), 472-489. doi:10.1007/s11524-015-9949-0
- Knowles, Z. R., Parnell, D., Stratton, G., & Ridgers, N. D. (2013). Learning from the experts: exploring playground experience and activities using a write and draw technique. *J Phys Act Health*, 10(3), 406-415.
- Kohl, H. W., Craig, C. L., Lambert, E. V., Inoue, S., Alkandari, J. R., Leetongin, G., & Kahlmeier, S. (2012). The pandemic of physical inactivity: global action for public health. *The Lancet*, 380(9838), 294-305. doi:[https://doi.org/10.1016/S0140-6736\(12\)60898-8](https://doi.org/10.1016/S0140-6736(12)60898-8)
- Kriemler, S., Meyer, U., Martin, E., Sluijs, E. M., Andersen, L. B., & Martin, B. W. (2011). Effect of school-based interventions on physical activity and fitness in children and adolescents: a review of reviews and systematic update. *Br J Sports Med*, 45. doi:10.1136/bjsports-2011-090186
- Kriemler, S., Zahner, L., Schindler, C., Meyer, U., Hartmann, T., Hebestreit, H., . . . Puder, J. J. (2010). Effect of school based physical activity programme (KISS) on fitness and adiposity in primary schoolchildren: cluster randomised controlled trial. *BMJ*, 340.
- Lai, S. K., Costigan, S. A., Morgan, P. J., Lubans, D. R., Stodden, D. F., Salmon, J., & Barnett, L. M. (2014). Do School-Based Interventions Focusing on Physical

- Activity, Fitness, or Fundamental Movement Skill Competency Produce a Sustained Impact in These Outcomes in Children and Adolescents? A Systematic Review of Follow-Up Studies. *Sports Medicine*, 44(1), 67-79. doi:10.1007/s40279-013-0099-9
- Laine, H., Araujo-Soares, V., Haukkala, A., & Hankonen, N. (2016). Acceptability of Strategies to Reduce Student Sitting: A Mixed-Methods Study With College Teachers. *Health Promot Pract*. doi:10.1177/1524839916677209
- Lau, E. Y., Dowda, M., McIver, K. L., & Pate, R. R. (2017). Changes in Physical Activity in the School, Afterschool, and Evening Periods During the Transition From Elementary to Middle School. *J Sch Health*, 87(7), 531-537. doi:10.1111/josh.1252
- Lawlor, D. A., Jago, R., Noble, S. M., Chittleborough, C. R., Campbell, R., Mytton, J., . . . Kipping, R. R. (2011). The Active for Life Year 5 (AFLY5) school based cluster randomised controlled trial: study protocol for a randomized controlled trial. *Trials*, 12, 181. doi:10.1186/1745-6215-12-181
- Lee, S. M., Burgeson, C. R., Fulton, J. E., & Spain, C. G. (2007). Physical education and physical activity: results from the School Health Policies and Programs Study 2006. *J Sch Health*, 77(8), 435-463. doi:10.1111/j.1746-1561.2007.00229.x
- Liu, N., Plowman, S. A., & Looney, M. A. (1992). The Reliability and Validity of the 20-Meter Shuttle Test in American Students 12 to 15 Years Old. *Res Q Exerc Sport*, 63(4), 360-365. doi:10.1080/02701367.1992.10608757
- Lloyd, J., Dean, S., Creanor, S., Abraham, C., Hillsdon, M., Ryan, E., & Wyatt, K. M. (2017). Intervention fidelity in the definitive cluster randomised controlled trial of the Healthy Lifestyles Programme (HeLP) trial: findings from the process

- evaluation. *International Journal of Behavioral Nutrition and Physical Activity*, 14(1), 163. doi:10.1186/s12966-017-0616-6
- Loman, D. G. (2008). Promoting physical activity in teen girls: insight from focus groups. *MCN Am J Matern Child Nurs*, 33. doi:10.1097/01.nmc.0000334896.91720.86
- Lonsdale, C., Rosenkranz, R. R., Peralta, L. R., Bennie, A., Fahey, P., & Lubans, D. R. (2013). A systematic review and meta-analysis of interventions designed to increase moderate-to-vigorous physical activity in school physical education lessons. *Preventive Medicine*, 56(2), 152-161. doi:<https://doi.org/10.1016/j.ypmed.2012.12.004>
- Loprinzi, P. D., & Cardinal, B. J. (2011). Measuring Children's Physical Activity and Sedentary Behaviors. *Journal of Exercise Science & Fitness*, 9(1), 15-23. doi:[https://doi.org/10.1016/S1728-869X\(11\)60002-6](https://doi.org/10.1016/S1728-869X(11)60002-6)
- Lounsbery M, A. F., McKenzie, T. L., Morrow, J. J. R., Holt, K. A., & Budnar, R. G. (2013). School physical activity policy assessment. *Journal of physical activity & health*, 10(4), 496.
- Lubans, D., Richards, J., Hillman, C., Faulkner, G., Beauchamp, M., Nilsson, M., . . . Biddle, S. (2016). Physical Activity for Cognitive and Mental Health in Youth: A Systematic Review of Mechanisms. *Pediatrics*. doi:10.1542/peds.2016-1642
- Lubans, D. R., Lonsdale, C., Cohen, K., Eather, N., Beauchamp, M. R., Morgan, P. J., . . . Smith, J. J. (2017). Framework for the design and delivery of organized physical activity sessions for children and adolescents: rationale and description of the 'SAAFE' teaching principles. *Int J Behav Nutr Phys Act*, 14(1), 24. doi:10.1186/s12966-017-0479-x

- Lubans, D. R., Morgan, P. J., Weaver, K., Callister, R., Dewar, D. L., Costigan, S. A., . . . Plotnikoff, R. C. (2012). Rationale and study protocol for the supporting children's outcomes using rewards, exercise and skills (SCORES) group randomized controlled trial: A physical activity and fundamental movement skills intervention for primary schools in low-income communities. *BMC public health*, 12(1), 427. doi:10.1186/1471-2458-12-427
- Macdonald, H. M., Kontulainen, S. A., Khan, K. M., & McKay, H. A. (2007). Is a school-based physical activity intervention effective for increasing tibial bone strength in boys and girls? *J Bone Miner Res*, 22(3), 434-446. doi:10.1359/jbmr.061205
- Mackintosh, K. A., Knowles, Z. R., Ridgers, N. D., & Fairclough, S. J. (2011). Using formative research to develop CHANGE!: a curriculum-based physical activity promoting intervention. *BMC public health*, 11(1), 831. doi:10.1186/1471-2458-11-831
- Mann, K. D., Howe, L. D., Basterfield, L., Parkinson, K. N., Pearce, M. S., Reilly, J. K., . . . Janssen, X. (2017). Longitudinal study of the associations between change in sedentary behavior and change in adiposity during childhood and adolescence: Gateshead Millennium Study. *Int J Obes (Lond)*, 41(7), 1042-1047. doi:10.1038/ijo.2017.69
- Mark, A. E., & Janssen, I. (2008). Relationship between screen time and metabolic syndrome in adolescents. *J Public Health (Oxf)*, 30(2), 153-160. doi:10.1093/pubmed/fdn022
- Marshall, S. J., Biddle, S. J. H., Sallis, J. F., McKenzie, T. L., & Conway, T. L. (2002). Clustering of Sedentary Behaviors and Physical Activity among Youth: A Cross-

- National Study. *Pediatric exercise science*, 14(4), 401-417.
doi:10.1123/pes.14.4.401
- Martin, R., & Murtagh, E. M. (2017a). Active Classrooms: A Cluster Randomized Controlled Trial Evaluating the Effects of a Movement Integration Intervention on the Physical Activity Levels of Primary School Children. *Journal of physical activity & health*, 14(4), 290-300.
- Martin, R., & Murtagh, E. M. (2017b). Effect of Active Lessons on Physical Activity, Academic, and Health Outcomes: A Systematic Review. *Res Q Exerc Sport*, 88(2), 149-168. doi:10.1080/02701367.2017.1294244
- Martin, R., & Murtagh, E. M. (2017c). Teachers' and students' perspectives of participating in the 'Active Classrooms' movement integration programme. *Teaching and Teacher Education*, 63, 218-230.
doi:<https://doi.org/10.1016/j.tate.2017.01.002>
- Masse, L. C., Fuemmeler, B. F., Anderson, C. B., Matthews, C. E., Trost, S. G., Catellier, D. J., & Treuth, M. (2005). Accelerometer data reduction: a comparison of four reduction algorithms on select outcome variables. *Med Sci Sports Exerc*, 37(11 Suppl), S544-554.
- McKay, H., MacLean, L., Petit, M., MacKelvie-O'Brien, K., Janssen, P., Beck, T., & Khan, K. (2005). "Bounce at the Bell": a novel program of short bouts of exercise improves proximal femur bone mass in early pubertal children. *British Journal of Sports Medicine*, 39(8), 521-526. doi:10.1136/bjsm.2004.014266
- McKenzie, T. L., Sallis, J. F., Rosengard, P., & Ballard, K. (2016). The SPARK Programs: A Public Health Model of Physical Education Research and Dissemination.

- Journal of Teaching in Physical Education*, 35(4), 381-389.
doi:10.1123/jtpe.2016-0100
- McLeroy, K. R., Bibeau, D., Steckler, A., & Glanz, K. (1988). An Ecological Perspective on Health Promotion Programs. *Health Education Quarterly*, 15(4), 351-377.
doi:10.1177/109019818801500401
- McMullen, J., Kulinna, P., & Cothran, D. (2014). Physical Activity Opportunities During the School Day: Classroom Teachers' Perceptions of Using Activity Breaks in the Classroom. *Journal of Teaching in Physical Education*, 33(4), 511-527.
doi:10.1123/jtpe.2014-0062
- McWhirter, J. (2014). The draw and write technique as a versatile tool for researching children's understanding of health and well-being. *International Journal of Health Promotion and Education*, 52(5), 250-259.
doi:10.1080/14635240.2014.912123
- Meyer, U., Roth, R., Zahner, L., Gerber, M., Puder, J. J., Hebestreit, H., & Kriemler, S. (2013). Contribution of physical education to overall physical activity. *Scand J Med Sci Sports*, 23(5), 600-606. doi:10.1111/j.1600-0838.2011.01425.x
- Mindell, J., Ison, E., & Joffe, M. (2003). A glossary for health impact assessment. *J Epidemiol Community Health*, 57(6), 647-651. doi:10.1136/jech.57.9.647
- Møller, N. C., Tarp, J., Kamelarczyk, E. F., Brønd, J. C., Klakk, H., & Wedderkopp, N. (2014). Do extra compulsory physical education lessons mean more physically active children - findings from the childhood health, activity, and motor performance school study Denmark (The CHAMPS-study DK). *The international journal of behavioral nutrition and physical activity*, 11, 121.
doi:10.1186/s12966-014-0121-0

- Molnar, B. E., Gortmaker, S. L., Bull, F. C., & Buka, S. L. (2004). Unsafe to play? Neighborhood disorder and lack of safety predict reduced physical activity among urban children and adolescents. *Am J Health Promot*, 18(5), 378-386. doi:10.4278/0890-1171-18.5.378
- Moore, G. F., Audrey, S., Barker, M., Bond, L., Bonell, C., & Hardeman, W. (2015). Process evaluation of complex interventions: Medical Research Council guidance. *BMJ*, 350. doi:10.1136/bmj.h1258
- Moore, G. F., Audrey, S., Barker, M., Bond, L., Bonell, C., Hardeman, W., . . . Baird, J. (2015). Process evaluation of complex interventions: Medical Research Council guidance. *BMJ : British Medical Journal*, 350. doi:10.1136/bmj.h1258
- Mooses, K., Pihu, M., Riso, E. M., Hannus, A., Kaasik, P., & Kull, M. (2017). Physical Education Increases Daily Moderate to Vigorous Physical Activity and Reduces Sedentary Time. *J Sch Health*, 87(8), 602-607. doi:10.1111/josh.12530
- Mura, G., Vellante, M., Nardi, A. E., Machado, S., & Carta, M. G. (2015). Effects of School-Based Physical Activity Interventions on Cognition and Academic Achievement: A Systematic Review. *CNS Neurol Disord Drug Targets*, 14(9), 1194-1208.
- Murillo Pardo, B., García Bengoechea, E., Generelo Lanaspa, E., Bush, P. L., Zaragoza Casterad, J., Julián Clemente, J. A., & García González, L. (2013). Promising school-based strategies and intervention guidelines to increase physical activity of adolescents. *Health Education Research*, 28(3), 523-538. doi:10.1093/her/cyt040
- Nathan, N., Elton, B., Babic, M., McCarthy, N., Sutherland, R., Pesseau, J., . . . Wolfenden, L. (2018). Barriers and facilitators to the implementation of

physical activity policies in schools: A systematic review. *Prev Med*, 107, 45-53.

doi:10.1016/j.ypmed.2017.11.012

Nathan, N., Sutherland, R., Beauchamp, M. R., Cohen, K., Hulteen, R. M., Babic, M., . .

. Lubans, D. R. (2017). Feasibility and efficacy of the Great Leaders Active Students (GLASS) program on children's physical activity and object control skill competency: A non-randomised trial. *J Sci Med Sport*, 20(12), 1081-1086.

doi:10.1016/j.jsams.2017.04.016

National Statistics. (2012). 2011 Census - Results. Key Statistics at Borough Level.

National Statistics. (2016). *Health Survey for England, 2015*. Retrieved from

<https://digital.nhs.uk/data-and-information/publications/statistical/health-survey-for-england/health-survey-for-england-2015>.

National Statistics. (2017a). *National Child Measurement Programme - England, 2016-*

17. Retrieved from <https://digital.nhs.uk/data-and-information/publications/statistical/national-child-measurement-programme/2016-17-school-year>.

National Statistics. (2017b). *Health Survey for England, 2016*. Retrieved from

<https://digital.nhs.uk/data-and-information/publications/statistical/health-survey-for-england/health-survey-for-england-2016>.

Naylor, P. J., Macdonald, H. M., Reed, K. E., & McKay, H. A. (2006). Action Schools! BC:

A Socioecological Approach to Modifying Chronic Disease Risk Factors in Elementary School Children. *Preventing Chronic Disease*, 3(2), A60.

Naylor, P. J., Macdonald, H. M., Warburton, D. E. R., Reed, K. E., & McKay, H. A. (2008).

An active school model to promote physical activity in elementary schools: Action schools! BC. *British Journal of Sports Medicine*, 42(5), 338.

- Naylor, P. J., Macdonald, H. M., Zebedee, J. A., Reed, K. E., & McKay, H. A. (2006). Lessons learned from Action Schools! BC - An 'active school' model to promote physical activity in elementary schools. *J Sci Med Sport*, 9(5), 413-423. doi:10.1016/j.jsams.2006.06.013
- Naylor, P. J., & McKay, H. A. (2009). Prevention in the first place: schools a setting for action on physical inactivity. *Br J Sports Med*, 43(1), 10-13. doi:10.1136/bjsm.2008.053447
- Naylor, P. J., Nettlefold, L., Race, D., Hoy, C., Ashe, M. C., Wharf Higgins, J., & McKay, H. A. (2015). Implementation of school based physical activity interventions: a systematic review. *Prev Med*, 72, 95-115. doi:10.1016/j.ypmed.2014.12.034
- Naylor, P. J., Scott, J., Drummond, J., Bridgewater, L., McKay, H. A., & Panagiotopoulos, C. (2010). Implementing a whole school physical activity and healthy eating model in rural and remote first nations schools: a process evaluation of action schools! BC. *Rural Remote Health*, 10(2), 1296.
- Nettlefold, L., McKay, H. A., Warburton, D. E. R., McGuire, K. A., Bredin, S. S. D., & Naylor, P. J. (2011). The challenge of low physical activity during the school day: at recess, lunch and in physical education. *British Journal of Sports Medicine*, 45(10), 813.
- Noonan, R. J., Boddy, L. M., Fairclough, S. J., & Knowles, Z. R. (2016). Write, draw, show, and tell: a child-centred dual methodology to explore perceptions of out-of-school physical activity. *BMC public health*, 16, 326. doi:10.1186/s12889-016-3005-1
- Noonan, R. J., Boddy, L. M., Fairclough, S. J., & Knowles, Z. R. (2017). Parental perceptions on childrens out-of-school physical activity and family-based

physical activity. *Early Child Development and Care*, 187(12), 1909-1924.

doi:10.1080/03004430.2016.1194409

Noonan, R. J., Boddy, L. M., Knowles, Z. R., & Fairclough, S. J. (2016). Cross-sectional associations between high-deprivation home and neighbourhood environments, and health-related variables among Liverpool children. *BMJ Open*, 6(1).

Noonan, R. J., Fairclough, S. J., Knowles, Z. R., & Boddy, L. M. (2017). One Size Does Not Fit All: Contextualising Family Physical Activity Using a Write, Draw, Show and Tell Approach. *Children*, 4(7). doi:10.3390/children4070059

Nusser, S. M., Beyler, N. K., Welk, G. J., Carriquiry, A. L., Fuller, W. A., & King, B. M. (2012). Modeling errors in physical activity recall data. *J Phys Act Health*, 9 Suppl 1, S56-67.

Okely, A. D., Lubans, D. R., Morgan, P. J., Cotton, W., Peralta, L., Miller, J., . . . Janssen, X. (2017). Promoting physical activity among adolescent girls: the Girls in Sport group randomized trial. *International Journal of Behavioral Nutrition and Physical Activity*, 14(1), 81. doi:10.1186/s12966-017-0535-6

Owen, M. B., Curry, W. B., Kerner, C., Newson, L., & Fairclough, S. J. (2017). The effectiveness of school-based physical activity interventions for adolescent girls: A systematic review and meta-analysis. *Prev Med*, 105, 237-249. doi:10.1016/j.ypmed.2017.09.018

Page, A. S., Cooper, A. R., Griew, P., & Jago, R. (2010). Children's Screen Viewing is Related to Psychological Difficulties Irrespective of Physical Activity. *Pediatrics*.

Panoulas, V. F., Ahmad, N., Fazal, A. A., Kassamali, R. H., Nightingale, P., Kitas, G. D., & Labib, M. (2008). The inter-operator variability in measuring waist

- circumference and its potential impact on the diagnosis of the metabolic syndrome. *Postgrad Med J*, 84(993), 344-347. doi:10.1136/pgmj.2008.068825.
- Parrish, A. M., Yeatman, H., Iverson, D., & Russell, K. (2012). Using interviews and peer pairs to better understand how school environments affect young children's playground physical activity levels: a qualitative study. *Health Educ Res*, 27(2), 269-280. doi:10.1093/her/cyr049
- Pate, R. R., Mitchell, J. A., Byun, W., & Dowda, M. (2011). Sedentary behaviour in youth. *British Journal of Sports Medicine*, 45(11), 906.
- Pate, R. R., O'Neill, J. R., & Lobelo, F. (2008). The evolving definition of "sedentary". *Exerc Sport Sci Rev*, 36(4), 173-178. doi:10.1097/JES.0b013e3181877d1a
- Patton, M. Q. (1999). Enhancing the quality and credibility of qualitative analysis. *Health Services Research*, 34(5 Pt 2), 1189-1208.
- Peach, D., Van Hoomissen, J., & Callender, H. L. (2014). Exploring the ActiLife((R)) filtration algorithm: converting raw acceleration data to counts. *Physiol Meas*, 35(12), 2359-2367. doi:10.1088/0967-3334/35/12/2359
- Pedišić, Ž., & Bauman, A. (2015). Accelerometer-based measures in physical activity surveillance: current practices and issues. *British Journal of Sports Medicine*, 49(4), 219.
- Perry, C. K., Ackert, E., Sallis, J. F., Glanz, K., & Saelens, B. E. (2016). Places where children are active: A longitudinal examination of children's physical activity. *Preventive Medicine*, 93, 88-95. doi:<https://doi.org/10.1016/j.ypmed.2016.09.015>
- Poitras, V. J., Gray, C. E., Borghese, M. M., Carson, V., Chaput, J. P., Janssen, I., . . . Tremblay, M. S. (2016). Systematic review of the relationships between

- objectively measured physical activity and health indicators in school-aged children and youth. *Appl Physiol Nutr Metab*, 41(6 Suppl 3), S197-239. doi:10.1139/apnm-2015-0663
- Pokorny, S. B., Jason, L. A., Schoeny, M. E., Townsend, S. M., & Curie, C. J. (2001). Do participation rates change when active consent procedures replace passive consent. *Eval Rev*, 25(5), 567-580. doi:10.1177/0193841x0102500504
- Porcellato, L., Dughill, L., & Springett, J. (2002). Using focus groups to explore children's perceptions of smoking: reflections on practice. *Health Education*, 102(6), 310-320. doi:10.1108/09654280210446856
- Pouliou, T., Sera, F., Griffiths, L., Joshi, H., Geraci, M., Cortina-Borja, M., & Law, C. (2015). Environmental influences on children's physical activity. *Journal of Epidemiology and Community Health*, 69(1), 77.
- Powell, E., Woodfield, L. A., & Nevill, A. M. (2016). Increasing physical activity levels in primary school physical education: The SHARP Principles Model. *Preventive Medicine Reports*, 3, 7-13. doi:10.1016/j.pmedr.2015.11.007
- Price, L., Wyatt, K., Lloyd, J., Abraham, C., Creanor, S., Dean, S., & Hillsdon, M. (2018). Children's Compliance With Wrist-Worn Accelerometry Within a Cluster-Randomized Controlled Trial: Findings From the Healthy Lifestyles Programme. *Pediatr Exerc Sci*, 30(2), 281-287. doi:10.1123/pes.2017-0179
- Psaki, S. R., Seidman, J. C., Miller, M., Gottlieb, M., Bhutta, Z. A., Ahmed, T., . . . Checkley, W. (2014). Measuring socioeconomic status in multicountry studies: results from the eight-country MAL-ED study. *Popul Health Metr*, 12(8). doi:10.1186/1478-7954-12-8
- Public Health Engalnd (2017a). *Understanding health inequalities in England*. London.

- Public Health England. (2017b). *National Child Measurement Programme Operational Guidance*. London.
- Pulsford, R. M., Griew, P., Page, A. S., Cooper, A. R., & Hillsdon, M. M. (2013). Socioeconomic position and childhood sedentary time: evidence from the PEACH project. *Int J Behav Nutr Phys Act*, 10, 105. doi:10.1186/1479-5868-10-105
- Quarmby, T., Daly-Smith, A., & Kime, N. (2018). 'You get some very archaic ideas of what teaching is ...': primary school teachers' perceptions of the barriers to physically active lessons. *Education 3-13*, 1-14. doi:10.1080/03004279.2018.1437462
- Rabesh, J., Charlton, C., Browne, W. J., Healy, M., & Cameron, B. (2009). *MLwiN Version 2.10*. Retrieved from Centre for Multilevel Modelling, University of Bristol.:
- Ratel, S., Lazaar, N., Dore, E., Baquet, G., Williams, C. A., Berthoin, S., . . . Duche, P. (2004). High-intensity intermittent activities at school: controversies and facts. *JOURNAL OF SPORTS MEDICINE AND PHYSICAL FITNESS*, 44(3), 272-280.
- Reilly, J. J., Johnston, G., McIntosh, S., & Martin, A. (2016). Contribution of School Recess to Daily Physical Activity: Systematic Review and Evidence Appraisal. *Health Behavior and Policy Review*, 3(6), 581-589. doi:10.14485/HBPR.3.6.7
- Rich, C., Geraci, M., Griffiths, L., Sera, F., Dezateux, C., & Cortina-Borja, M. (2013). Quality Control Methods in Accelerometer Data Processing: Defining Minimum Wear Time. *PLoS One*, 8(6), e67206. doi:10.1371/journal.pone.0067206
- Richmond, R. C., Davey Smith, G., Ness, A. R., den Hoed, M., McMahon, G., & Timpson, N. J. (2014). Assessing Causality in the Association between Child Adiposity and

- Physical Activity Levels: A Mendelian Randomization Analysis. *PLOS Medicine*, 11(3), e1001618. doi:10.1371/journal.pmed.1001618
- Ridgers, N. D., Fairclough, S. J., & Stratton, G. (2010). Variables associated with children's physical activity levels during recess: the A-CLASS project. *International Journal of Behavioral Nutrition and Physical Activity*, 7(1), 74. doi:10.1186/1479-5868-7-74
- Ridgers, N. D., Knowles, Z. R., & Sayers, J. (2012). Encouraging play in the natural environment: a child-focused case study of Forest School. *Children's Geographies*, 10(1), 49-65. doi:10.1080/14733285.2011.638176
- Ridgers, N. D., Salmon, J., Parrish, A.-M., Stanley, R. M., & Okely, A. D. (2012). Physical Activity During School Recess: A Systematic Review. *American Journal of Preventive Medicine*, 43(3), 320-328. doi:<https://doi.org/10.1016/j.amepre.2012.05.019>
- Ridgers, N. D., Stratton, G., & Fairclough, S. J. (2006). Physical activity levels of children during school playtime. *Sports Med*, 36(4), 359-371.
- Ridgers, N. D., Stratton, G., Fairclough, S. J., & Twisk, J. W. R. (2007). Long-term effects of a playground markings and physical structures on children's recess physical activity levels. *Preventive Medicine*, 44(5), 393-397. doi:<https://doi.org/10.1016/j.ypmed.2007.01.009>
- Ridgers, N. D., Stratton, G., & McKenzie, T. L. (2010). Reliability and validity of the System for Observing Children's Activity and Relationships during Play (SOCARP). *J Phys Act Health*, 7(1), 17-25.
- Ridgers, N. D., Timperio, A., Cerin, E., & Salmon, J. O. (2014). Compensation of Physical Activity and Sedentary Time in Primary School Children. *Medicine and science*

in sports and exercise, 46(8), 1564-1569.

doi:10.1249/MSS.0000000000000275

Riley, N., Lubans, D., Holmes, K., Hansen, V., Gore, J., & Morgan, P. (2017). Movement-based Mathematics: Enjoyment and Engagement without Compromising Learning through the EASY Minds Program. *Eurasia Journal of Mathematics, Science and Technology Education*, 13(6), 1653-1673.
doi:10.12973/eurasia.2017.00690a

Riley, N., Lubans, D. R., Morgan, P. J., & Young, M. (2015). Outcomes and process evaluation of a programme integrating physical activity into the primary school mathematics curriculum: The EASY Minds pilot randomised controlled trial. *J Sci Med Sport*, 18(6), 656-661.
doi:<https://doi.org/10.1016/j.jsams.2014.09.005>

Roberts, S. J., Fairclough, S. J., Ridgers, N. D., & Porteous, C. (2012). An observational assessment of physical activity levels and social behaviour during elementary school recess. *Health Education Journal*, 72(3), 254-262.
doi:10.1177/0017896912439126

Rosenberger, M. E., Haskell, W. L., Albinali, F., Mota, S., Nawyn, J., & Intille, S. (2013). Estimating activity and sedentary behavior from an accelerometer on the hip or wrist. *Med Sci Sports Exerc*, 45(5), 964-975.
doi:10.1249/MSS.0b013e31827f0d9c

Routen, A. C., Biddle, S. J. H., Bodicoat, D. H., Cale, L., Clemes, S., Edwardson, C. L., . . . Sherar, L. B. (2017). Study design and protocol for a mixed methods evaluation of an intervention to reduce and break up sitting time in primary school

- classrooms in the UK: The CLASS PAL (Physically Active Learning) Programme. *BMJ Open*, 7(11).
- Routen, A. C., Johnston, J. P., Glazebrook, C., & Sherar, L. B. (2018). Teacher perceptions on the delivery and implementation of movement integration strategies: The CLASS PAL (Physically Active Learning) Programme. *International Journal of Educational Research*, 88, 48-59. doi:<https://doi.org/10.1016/j.ijer.2018.01.003>
- Rowlands, A. V. (2007). Accelerometer assessment of physical activity in children: an update. *Pediatr Exerc Sci*, 19(3), 252-266.
- Rowlands, A. V., Edwardson, C. L., Davies, M. J., Khunti, K., Harrington, D. M., & Yates, T. (2018). Beyond Cut Points: Accelerometer Metrics that Capture the Physical Activity Profile. *Med Sci Sports Exerc*, 50(6), 1323-1332. doi:10.1249/mss.0000000000001561
- Rowlands, A. V., & Eston, R. G. (2007). The Measurement and Interpretation of Children's Physical Activity. *Journal of Sports Science & Medicine*, 6(3), 270-276.
- Rowlands, A. V., Mirkes, E. M., Yates, T., Clemes, S., Davies, M., Khunti, K., & Edwardson, C. L. (2018). Accelerometer-assessed Physical Activity in Epidemiology: Are Monitors Equivalent? *Med Sci Sports Exerc*, 50(2), 257-265. doi:10.1249/mss.0000000000001435
- Ruiz, J. R., Ortega, F. B., Martínez-Gómez, D., Labayen, I., Moreno, L. A., De Bourdeaudhuij, I., . . . on behalf of the, H. S. G. (2011). Objectively Measured Physical Activity and Sedentary Time in European AdolescentsThe HELENA

- Study. *American Journal of Epidemiology*, 174(2), 173-184.
doi:10.1093/aje/kwr068
- Russ, L. B., Webster, C. A., Beets, M. W., & Phillips, D. S. (2015). Systematic Review and Meta-Analysis of Multi-Component Interventions Through Schools to Increase Physical Activity. *J Phys Act Health*, 12(10), 1436-1446. doi:10.1123/jpah.2014-0244
- Sabia, S., van Hees, V. T., Shipley, M. J., Trenell, M. I., Hagger-Johnson, G., Elbaz, A., . . . Singh-Manoux, A. (2014). Association Between Questionnaire- and Accelerometer-Assessed Physical Activity: The Role of Sociodemographic Factors. *American Journal of Epidemiology*, 179(6), 781-790. doi:10.1093/aje/kwt330
- Sacheck, J. M., Wright, C., Amin, S., Anzman-Frasca, S., Chomitz, V., Chui, K., . . . Economos, C. (2017). The Fueling Learning Through Exercise (FLEX) Study: Short-term Findings On Sedentary Time In Lower-income Schoolchildren. *May 31 445 PM - 500 PM. Medicine & Science in Sports & Exercise*, 49(5S), 200-201. doi:10.1249/01.mss.0000517388.58323.d7
- Sallis, J. F., Bull, F., Guthold, R., Heath, G. W., Inoue, S., Kelly, S., . . . Hallal, P. C. (2016). Progress in physical activity over the Olympic quadrennium. *The Lancet*, 338(10051), 1325-1336. doi:https://doi.org/10.1016/S0140-6736(16)30581-5
- Sallis, J. F., Cervero, R. B., Ascher, W., Henderson, K. A., Kraft, M. K., & Kerr, J. (2006). An ecological approach to creating active living communities. *Annu Rev Public Health*, 27, 297-322. doi:10.1146/annurev.publhealth.27.021405.102100

- Sallis, J. F., Owen, N., & Fotheringham, M. J. (2000). Behavioral epidemiology: a systematic framework to classify phases of research on health promotion and disease prevention. *Ann Behav Med*, 22(4), 294-298. doi:10.1007/bf02895665
- Sallis, J. F., Prochaska, J. J., & Taylor, W. C. (2000). A review of correlates of physical activity of children and adolescents. *Medicine and science in sports and exercise*, 32(5), 963-975. doi:10.1097/00005768-200005000-00014
- Salmon, J., Ball, K., Hume, C., Booth, M., & Crawford, D. (2008). Outcomes of a group-randomized trial to prevent excess weight, reduce screen behaviours and promote physical activity in 10-year-old children: Switch-Play. *Int J Obes*, 32(4), 601-612. doi:10.1038/sj.ijo.0803805
- Salmon, J., Brown, H., & Hume, C. (2009). Effects of strategies to promote children's physical activity on potential mediators. *Int J Obes (Lond)*, 33 Suppl 1, S66-73. doi:10.1038/ijo.2009.21
- Salmon, J., Tremblay, M. S., Marshall, S. J., & Hume, C. (2011). Health risks, correlates, and interventions to reduce sedentary behavior in young people. *Am J Prev Med*, 41(2), 197-206. doi:10.1016/j.amepre.2011.05.001
- Santelli, J. S., Smith Rogers, A., Rosenfeld, W. D., DuRant, R. H., Dubler, N., Morreale, M., . . . Schissel, A. (2003). Guidelines for adolescent health research. A position paper of the Society for Adolescent Medicine. *J Adolesc Health*, 33(5), 396-409.
- Santos, R., Mota, J., Okely, A. D., Pratt, M., Moreira, C., Coelho-e-Silva, M. J., . . . Sardinha, L. B. (2014). The independent associations of sedentary behaviour and physical activity on cardiorespiratory fitness. *British Journal of Sports Medicine*, 48(20), 1508.

- Saunders, T. J., Gray, C. E., Poitras, V. J., Chaput, J. P., Janssen, I., Katzmarzyk, P. T., . . . Carson, V. (2016). Combinations of physical activity, sedentary behaviour and sleep: relationships with health indicators in school-aged children and youth. *Appl Physiol Nutr Metab*, 41(6 Suppl 3), S283-293. doi:10.1139/apnm-2015-0626
- Saunders, T. J., & Vallance, J. K. (2017). Screen Time and Health Indicators Among Children and Youth: Current Evidence, Limitations and Future Directions. *Appl Health Econ Health Policy*, 15(3), 323-331. doi:10.1007/s40258-016-0289-3
- Sawka, K. J., McCormack, G. R., Nettel-Aguirre, A., Hawe, P., & Doyle-Baker, P. K. (2013). Friendship networks and physical activity and sedentary behavior among youth: a systematized review. *International Journal of Behavioral Nutrition and Physical Activity*, 10(1), 130. doi:10.1186/1479-5868-10-130
- Schranz, N. K., Olds, T., Boyd, R., Evans, J., Gomersall, S. R., Hardy, L., . . . Tomkinson, G. R. (2016). Results From Australia's 2016 Report Card on Physical Activity for Children and Youth. *Journal of Physical Activity and Health*, 13(11 Suppl 2), S87-S94. doi:10.1123/jpah.2016-0345
- Seabra, A., Mendonca, D., Maia, J., Welk, G., Brustad, R., Fonseca, A. M., & Seabra, A. F. (2013). Gender, weight status and socioeconomic differences in psychosocial correlates of physical activity in schoolchildren. *J Sci Med Sport*, 16(4), 320-326. doi:10.1016/j.jsams.2012.07.008
- Sedentary Behaviour Research Network. (2012). Letter to the editor: Standardized use of the terms "sedentary" and "sedentary behaviours". *Appl Physio Nutr Metab*, 37(3), 540-542. doi:10.1139/h2012-024.

- Shaghaghi, A., Bhopal, R. S., & Sheikh, A. (2011). Approaches to Recruiting 'Hard-To-Reach' Populations into Re-search: A Review of the Literature. *Health Promotion Perspectives*, 1(2), 86-94. doi:10.5681/hpp.2011.009
- Shah, S., Allison, K. R., Schoueri-Mychasiw, N., Pach, B., Manson, H., & Vu-Nguyen, K. (2017). A Review of Implementation Outcome Measures of School-Based Physical Activity Interventions. *J Sch Health*, 87(6), 474-486. doi:10.1111/josh.12514
- Sherar, L. B., Cumming, S. P., Eisenmann, J. C., Baxter-Jones, A. D. G., & Malina, R. M. (2010). Adolescent biological maturity and physical activity: biology meets behavior. *Pediatric exercise science*, 22(3), 332.
- Sherar, L. B., Griew, P., Esliger, D. W., Cooper, A. R., Ekelund, U., Judge, K., & Riddoch, C. (2011). International children's accelerometry database (ICAD): Design and methods. *BMC public health*, 11(1), 485. doi:10.1186/1471-2458-11-485
- Silva, D. A. S., Chaput, J. P., Katzmarzyk, P. T., Fogelholm, M., Hu, G., Maher, C., . . . Tremblay, M. S. (2018). Physical Education Classes, Physical Activity, and Sedentary Behavior in Children. *Med Sci Sports Exerc*, 50(5), 995-1004. doi:10.1249/mss.0000000000001524
- Silva, G., Andersen, L. B., Aires, L., Mota, J., Oliveira, J., & Ribeiro, J. C. (2013). Associations between sports participation, levels of moderate to vigorous physical activity and cardiorespiratory fitness in children and adolescents. *J Sports Sci*, 31(12), 1359-1367. doi:10.1080/02640414.2013.781666
- Smedegaard, S., Brondeel, R., Christiansen, L. B., & Skovgaard, T. (2017). What happened in the 'Move for Well-being in School': a process evaluation of a cluster randomized physical activity intervention using the RE-AIM framework.

International Journal of Behavioral Nutrition and Physical Activity, 14(1), 159.

doi:10.1186/s12966-017-0614-8

Smith, N. R., Clark, C., Fahy, A. E., Tharmaratnam, V., Lewis, D. J., Thompson, C., . . .

Cummins, S. (2012). The Olympic Regeneration in East London (ORiEL) study: protocol for a prospective controlled quasi-experiment to evaluate the impact of urban regeneration on young people and their families. *BMJ Open*, 2(4).

Solomon-Moore, E., Matthews, J., Reid, T., Toumpakari, Z., Sebire, S. J., Thompson, J.

L., . . . Jago, R. (2018). Examining the challenges posed to parents by the contemporary screen environments of children: a qualitative investigation.

BMC Pediatrics, 18(1), 129. doi:10.1186/s12887-018-1106-y

Spence, S., White, M., Adamson, A. J., & Matthews, J. N. S. (2015). Does the use of passive or active consent affect consent or completion rates, or dietary data quality? Repeat cross-sectional survey among school children aged 11–12 years. *BMJ Open*, 5(1). doi:10.1136/bmjopen-2014-006457

Spittaels, H., Van Cauwenberghe, E., Verbestel, V., De Meester, F., Van Dyck, D.,

Verloigne, M., . . . De Bourdeaudhuij, I. (2012). Objectively measured sedentary time and physical activity time across the lifespan: a cross-sectional study in four age groups. *International Journal of Behavioral Nutrition and Physical Activity*, 9(1), 149. doi:10.1186/1479-5868-9-149

Stalsberg, R., & Pedersen, A. V. (2010). Effects of socioeconomic status on the physical activity in adolescents: a systematic review of the evidence. *Scandinavian journal of medicine & science in sports*, 20(3), 368. doi:10.1111/j.1600-0838.2009.01047.x

- Standage, M., Wilkie, H. J., Jago, R., Foster, C., Goad, M. A., & Cumming, S. P. (2014). Results from England's 2014 Report Card on Physical Activity for Children and Youth. *J Phys Act Health, 11 Suppl 1*, S45-50. doi:10.1123/jpah.2014-0165
- Stanley, R. M., Boshoff, K., & Dollman, J. (2013). A Qualitative Exploration of the “Critical Window”: Factors Affecting Australian Children’s After-School Physical Activity. *Journal of Physical Activity and Health, 10*(1), 33-41. doi:10.1123/jpah.10.1.33
- Stanley, R. M., Ridley, K., & Dollman, J. (2012). Correlates of children's time-specific physical activity: a review of the literature. *The international journal of behavioral nutrition and physical activity, 9*(1), 50. doi:10.1186/1479-5868-9-50
- Stein, B. D., Jaycox, L. H., Langley, A., Kataoka, S. H., Wilkins, W. S., & Wong, M. (2007). Active parental consent for a school-based community violence screening: comparing distribution methods. *J Sch Health, 77*(3), 116-120. doi:10.1111/j.1746-1561.2007.00180.x
- Sterdt, E., Liersch, S., & Walter, U. (2013). Correlates of physical activity of children and adolescents: A systematic review of reviews. *Health Education Journal, 73*(1), 72-89. doi:10.1177/0017896912469578
- Stodden, D. F., Goodway, J. D., Langendorfer, S. J., Robertson, M. A., Rudisill, M. E., Garcia, C., & Garcia, L. E. (2008). A Developmental Perspective on the Role of Motor Skill Competence in Physical Activity: An Emergent Relationship. *Quest, 60*(2), 290-306. doi:10.1080/00336297.2008.10483582
- Strugnell, C., Orellana, L., Hayward, J., Millar, L., Swinburn, B., & Allender, S. (2018). Active (Opt-In) Consent Underestimates Mean BMI-z and the Prevalence of

Overweight and Obesity Compared to Passive (Opt-Out) Consent. Evidence from the Healthy Together Victoria and Childhood Obesity Study. *Int J Environ Res Public Health*, 15(4). doi:10.3390/ijerph15040747

Strugnell, C., Turner, K., Malakellis, M., Hayward, J., Foster, C., Millar, L., & Allender, S. (2016). Composition of objectively measured physical activity and sedentary behaviour participation across the school-day, influence of gender and weight status: cross-sectional analyses among disadvantaged Victorian school children. *BMJ Open*, 6(9).

Sullivan, R. A., Kuzel, A. H., Vaandering, M. E., & Chen, W. (2017). The Association of Physical Activity and Academic Behavior: A Systematic Review. *Journal of School Health*, 87(5), 388-398. doi:10.1111/josh.12502

Sutherland, R., Campbell, E., Lubans, D. R., Morgan, P. J., Okely, A. D., Nathan, N., . . . Wiggers, J. (2013). A cluster randomised trial of a school-based intervention to prevent decline in adolescent physical activity levels: study protocol for the 'Physical Activity 4 Everyone' trial. *BMC public health*, 13, 57. doi:10.1186/1471-2458-13-57

Sutherland, R., Campbell, E., Lubans, D. R., Morgan, P. J., Okely, A. D., Nathan, N., . . . Wiggers, J. (2016). 'Physical Activity 4 Everyone' school-based intervention to prevent decline in adolescent physical activity levels: 12 month (mid-intervention) report on a cluster randomised trial. *British Journal of Sports Medicine*, 50(8), 488-495. doi:10.1136/bjsports-2014-094523

Talarico, R., & Janssen, I. (2018). Compositional associations of time spent in sleep, sedentary behavior and physical activity with obesity measures in children. *International Journal of Obesity*. doi:10.1038/s41366-018-0053-x

- Tandon, P. S., Zhou, C., Sallis, J. F., Cain, K. L., Frank, L. D., & Saelens, B. E. (2012). Home environment relationships with children's physical activity, sedentary time, and screen time by socioeconomic status. *Int J Behav Nutr Phys Act*, 9, 88. doi:10.1186/1479-5868-9-88
- Taylor, R. W., Farmer, V. L., Cameron, S. L., Meredith-Jones, K., Williams, S. M., & Mann, J. I. (2011). School playgrounds and physical activity policies as predictors of school and home time activity. *Int J Behav Nutr Phys Act*, 8, 38. doi:10.1186/1479-5868-8-38
- Taylor, S. L., Curry, W. B., Knowles, Z. R., Noonan, R. J., McGrane, B., & Fairclough, S. J. (2017). Predictors of Segmented School Day Physical Activity and Sedentary Time in Children from a Northwest England Low-Income Community. *Int J Environ Res Public Health*, 14(5). doi:10.3390/ijerph14050534
- Teixeira, P. J., Carraça, E. V., Markland, D., Silva, M. N., & Ryan, R. M. (2012). Exercise, physical activity, and self-determination theory: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity*, 9(1), 78. doi:10.1186/1479-5868-9-78
- Telama, R. (2009). Tracking of Physical Activity from Childhood to Adulthood: A Review. *Obesity Facts*, 2(3), 187-195.
- Telama, R., Yang, X., Viikari, J., Valimaki, I., Wanne, O., & Raitakari, O. (2005). Physical activity from childhood to adulthood: a 21-year tracking study. *Am J Prev Med*, 28(3), 267-273. doi:10.1016/j.amepre.2004.12.003
- The Health and Social Care Information Centre. (2012). *Health Survey for England*. London.

- Thomas, J. R., Silverman, S., & Nelson, J. (2015). *Research Methods in Physical Activity* - 7th Edition. Champaign, IL: Human Kinetics.
- Tigges, B. B. (2003). Parental consent and adolescent risk behavior research. *J Nurs Scholarsh*, 35(3), 283-289.
- Till, J., Ferkins, L., & Handcock, P. (2011). Physical activity based professional development for teachers: The importance of whole school involvement. *Health Education Journal*, 70(2), 225-235. doi:10.1177/0017896910396218
- Tremblay, M. S., Aubert, S., Barnes, J. D., Saunders, T. J., Carson, V., Latimer-Cheung, A. E., . . . Chinapaw, M. J. M. (2017). Sedentary Behavior Research Network (SBRN) – Terminology Consensus Project process and outcome. *International Journal of Behavioral Nutrition and Physical Activity*, 14(1), 75. doi:10.1186/s12966-017-0525-8
- Tremblay, M. S., Barnes, J. D., Gonzalez, S. A., Katzmarzyk, P. T., Onywera, V. O., Reilly, J. J., & Tomkinson, G. R. (2016). Global Matrix 2.0: Report Card Grades on the Physical Activity of Children and Youth Comparing 38 Countries. *J Phys Act Health*, 13(11 Suppl 2), S343-s366. doi:10.1123/jpah.2016-0594
- Tremblay, M. S., Carson, V., Chaput, J. P., Connor Gorber, S., Dinh, T., Duggan, M., . . . Zehr, L. (2016). Canadian 24-Hour Movement Guidelines for Children and Youth: An Integration of Physical Activity, Sedentary Behaviour, and Sleep. *Appl Physiol Nutr Metab*, 41(6 Suppl 3), S311-327. doi:10.1139/apnm-2016-0151
- Trost, S. G., Loprinzi, P. D., Moore, R., & Pfeiffer, K. A. (2011). Comparison of Accelerometer Cut Points for Predicting Activity Intensity in Youth. *Medicine*

and science in sports and exercise, 43(7), 1360-1368.

doi:10.1249/MSS.0b013e318206476e

- Tudor-Locke, C., Barreira, T. V., Schuna, J. M., Mire, E. F., Chaput, J.-P., Fogelholm, M., . . . Katzmarzyk, P. T. (2015). Improving wear time compliance with a 24-hour waist-worn accelerometer protocol in the International Study of Childhood Obesity, Lifestyle and the Environment (ISCOLE). *International Journal of Behavioral Nutrition and Physical Activity*, 12(1), 11. doi:10.1186/s12966-015-0172-x
- Turrell, G., Lynch, J. W., Leite, C., Raghunathan, T., & Kaplan, G. A. (2007). Socioeconomic disadvantage in childhood and across the life course and all-cause mortality and physical function in adulthood: evidence from the Alameda County Study. *J Epidemiol Community Health*, 61(8), 723-730. doi:10.1136/jech.2006.050609
- Twisk, J. W. R. (2006). *Applied Multilevel Analysis*. Cambridge, United Kingdom: Cambridge University Press.
- U.S. Department of Health and Human Services. (2008a). *2008 Physical Activity Guidelines for Americans*. Washington.
- U.S. Department of Health and Human Services. (2008b). *Physical Activity Guidelines Advisory Committee Report*. Washington.
- Unger, J. B., Gallaher, P., Palmer, P. H., Baezconde-Garbanati, L., Trinidad, D. R., Cen, S., & Johnson, C. A. (2004). Characteristics of adolescents who provide neither parental consent nor refusal for participation in school-based survey research. *Eval Rev*, 28(1), 52-63. doi:10.1177/0193841x03254421

- van den Berg, V., Salimi, R., de Groot, R. H. M., Jolles, J., Chinapaw, M. J. M., & Singh, A. S. (2017). "It's a Battle... You Want to Do It, but How Will You Get It Done?": Teachers' and Principals' Perceptions of Implementing Additional Physical activity in School for Academic Performance. *Int J Environ Res Public Health*, 14(10), 1160. doi:10.3390/ijerph14101160
- van Grieken, A., Ezendam, N. P., Paulis, W. D., van der Wouden, J. C., & Raat, H. (2012). Primary prevention of overweight in children and adolescents: a meta-analysis of the effectiveness of interventions aiming to decrease sedentary behaviour. *Int J Behav Nutr Phys Act*, 9, 61. doi:10.1186/1479-5868-9-61
- van Hees, V. T., Sabia, S., Anderson, K. N., Denton, S. J., Oliver, J., Catt, M., . . . Singh-Manoux, A. (2015). A Novel, Open Access Method to Assess Sleep Duration Using a Wrist-Worn Accelerometer. *PLoS One*, 10(11), e0142533. doi:10.1371/journal.pone.0142533
- Van Kann, D. H., Kremers, S. P., de Vries, N. K., de Vries, S. I., & Jansen, M. W. (2016). The effect of a school-centered multicomponent intervention on daily physical activity and sedentary behavior in primary school children: The Active Living study. *Prev Med*, 89, 64-69. doi:10.1016/j.ypmed.2016.05.022
- van Mechelen, W., Hlobil, H., Kemper, H. C. (1986). Validation of two running tests as estimates of maximal aerobic power in children. *Eur J Appl Physiol Occup Physiol*, 55(5), 503-506.
- van Sluijs, E. M. F., & Kriemler, S. (2016). Reflections on physical activity intervention research in young people – dos, don'ts, and critical thoughts. *International Journal of Behavioral Nutrition and Physical Activity*, 13(1), 25. doi:10.1186/s12966-016-0348-z

- van Sluijs, E. M. F., McMinn, A. M., & Griffin, S. J. (2007). Effectiveness of interventions to promote physical activity in children and adolescents: systematic review of controlled trials. *BMJ*, 335(7622), 703. doi:10.1136/bmj.39320.843947.BE
- van Stralen, M. M., Yildirim, M., Wulp, A., te Velde, S. J., Verloigne, M., Doessegger, A., . . . Chinapaw, M. J. M. (2014). Measured sedentary time and physical activity during the school day of European 10- to 12-year-old children: The ENERGY project. *J Sci Med Sport*, 17(2), 201-206. doi:<https://doi.org/10.1016/j.jsams.2013.04.019>
- Vander Ploeg, K. A., Maximova, K., McGavock, J., Davis, W., & Veugelers, P. (2014). Do school-based physical activity interventions increase or reduce inequalities in health? *Social Science & Medicine*, 112, 80-87. doi:<https://doi.org/10.1016/j.socscimed.2014.04.032>
- Veitch, J., Salmon, J., & Ball, K. (2010). Individual, social and physical environmental correlates of children's active free-play: a cross-sectional study. *Int J Behav Nutr Phys Act*, 7, 11. doi:10.1186/1479-5868-7-11
- Verstraete, S. J. M., Cardon, G. M., De Clercq, D. L. R., & De Bourdeaudhuij, I. M. M. (2006). Increasing children's physical activity levels during recess periods in elementary schools: the effects of providing game equipment. *European Journal of Public Health*, 16(4), 415-419. doi:10.1093/eurpub/ckl008
- Verstraete, S. J. M., Cardon, G. M., De Clercq, D. L. R., & De Bourdeaudhuij, I. M. M. (2007). Effectiveness of a two-year health-related physical education intervention in elementary schools. *Journal of Teaching in Physical Education*, 26(1), 20-34.

- Vincent, W. J., & Weir, J. P. (2012). *Statistics in Kinesiology* (Fourth Edition ed.). Champaign, Ill: Human Kinetics.
- Ward, J. S., Duncan, J. S., Jarden, A., & Stewart, T. (2016). The impact of children's exposure to greenspace on physical activity, cognitive development, emotional wellbeing, and ability to appraise risk. *Health & Place*, 40, 44-50. doi:<https://doi.org/10.1016/j.healthplace.2016.04.015>
- Watson, A., Timperio, A., Brown, H., Best, K., & Hesketh, K. D. (2017). Effect of classroom-based physical activity interventions on academic and physical activity outcomes: a systematic review and meta-analysis. *International Journal of Behavioral Nutrition and Physical Activity*, 14(1), 114. doi:10.1186/s12966-017-0569-9
- Watson, A., Timperio, A., Brown, H., & Hesketh, K. D. (2017). A primary school active break programme (ACTI-BREAK): study protocol for a pilot cluster randomised controlled trial. *Trials*, 18(1), 433. doi:10.1186/s13063-017-2163-5
- Weatherson, K. A., McKay, R., Gainforth, H. L., & Jung, M. E. (2017). Barriers and facilitators to the implementation of a school-based physical activity policy in Canada: application of the theoretical domains framework. *BMC public health*, 17(1), 835. doi:10.1186/s12889-017-4846-y
- Webster, C. A., Zarrett, N., Cook, B. S., Egan, C., Nesbitt, D., & Weaver, R. G. (2017). Movement integration in elementary classrooms: Teacher perceptions and implications for program planning. *Eval Program Plann*, 61, 134-143. doi:10.1016/j.evalprogplan.2016.12.011

- Welk, G. J. (1999). The Youth Physical Activity Promotion Model: A Conceptual Bridge Between Theory and Practice. *Quest*, 51(1), 5-23. doi:10.1080/00336297.1999.10484297
- Welk, G. J., McClain, J., & Ainsworth, B. E. (2012). Protocols for evaluating equivalency of accelerometry-based activity monitors. *Med Sci Sports Exerc*, 44(1 Suppl 1), S39-49. doi:10.1249/MSS.0b013e3182399d8f
- West Lancashire Borough Council. (2014). *West Lancashire Economy Study 2014*. Retrieved from <https://infrastructure.planninginspectorate.gov.uk/document/2744220>.
- Whitt-Glover, M. C., Ham, S. A., & Yancey, A. K. (2011). Instant Recess(R): a practical tool for increasing physical activity during the school day. *Prog Community Health Partnersh*, 5(3), 289-297. doi:10.1353/cpr.2011.0031
- Wilkie, H., Standage, M., Sherar, L., Cumming, S., Parnell, C., Davis, A., . . . Jago, R. (2016). Results From England's 2016 Report Card on Physical Activity for Children and Youth. *Journal of Physical Activity and Health*, 13(11 Suppl 2), S143-S149. doi:10.1123/jpah.2016-0298
- Wilkie, H. J., Standage, M., Gillison, F. B., Cumming, S. P., & Katzmarzyk, P. T. (2018). Correlates of intensity-specific physical activity in children aged 9–11 years: a multilevel analysis of UK data from the International Study of Childhood Obesity, Lifestyle and the Environment. *BMJ Open*, 8(2).
- Wilson, D. K., Van Horn, M. L., Kitzman-Ulrich, H., Saunders, R., Pate, R., Lawman, H. G., . . . Brown, P. V. (2011). Results of the "Active by Choice Today" (ACT) randomized trial for increasing physical activity in low-income and minority adolescents. *Health Psychol*, 30(4), 463-471. doi:10.1037/a0023390

- Wolfenden, L., Kypri, K., Freund, M., & Hodder, R. (2009). Obtaining active parental consent for school-based research: a guide for researchers. *Aust N Z J Public Health*, 33(3), 270-275. doi:10.1111/j.1753-6405.2009.00387.x
- Zahner, L., Puder, J. J., Roth, R., Schmid, M., Guldemann, R., Pühse, U., . . . Kriemler, S. (2006). A school-based physical activity program to improve health and fitness in children aged 6–13 years ("Kinder-Sportstudie KISS"): study design of a randomized controlled trial [ISRCTN15360785]. *BMC public health*, 6, 147-147. doi:10.1186/1471-2458-6-147
- Zaqout, M., Vyncke, K., Moreno, L. A., De Miguel-Etayo, P., Lauria, F., Molnar, D., . . . Michels, N. (2016). Determinant factors of physical fitness in European children. *International Journal of Public Health*, 61(5), 573-582. doi:10.1007/s00038-016-0811-2
- Zhang, S., Murray, P., Zillmer, R., Eston, R. G., Catt, M., & Rowlands, A. V. (2012). Activity classification using the GENE: optimum sampling frequency and number of axes. *Med Sci Sports Exerc*, 44(11), 2228-2234. doi:10.1249/MSS.0b013e31825e19fd

Appendices

Appendix 1: Refusing Consent, Consent and Assent Forms

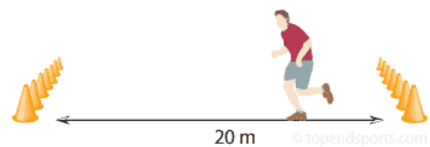



ACTIVE SCHOOLS: SKELMERSDALE

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Parent/Carer Information

We would like to invite your son/daughter to take part in a research project aiming to improve health and wellbeing in West Lancashire children. With the help of the project your child's school will try new ways to increase children's physical activity levels and we will evaluate how successful this has been by asking children to take part in the following activities:

- **Questionnaires** – Surveys will ask about the types of activities done and how often for the previous 7 days. Questions about children's thoughts on taking part in physical activity will also be included.
- **Measure of fitness** – 20m multi-stage shuttle run test. Children can stop whenever they wish but are encouraged to complete shuttle runs until they cannot keep pace with audible bleeps. 
- **Height, weight, waist circumference** – These measures will take place away from the rest of the group. No one but the researcher will see the results, they will not be made available to the school and will not be sent home, unless requested.
- **Physical activity monitoring** – A small activity monitor will be handed out and children will be asked to wear this for 7 consecutive days. It is worn on the wrist like a watch and should only be removed during water based activities like swimming/showering. 
- **Focus groups** – Researchers will ask groups of children about their thoughts on the new ways in which their school has tried to increase physical activity, for example what they liked or enjoyed and what they didn't like. The audio of these conversations will be recorded but the children will remain anonymous and their opinions voiced will remain confidential.
- We will also ask children for their date of birth and home postcode.

All information about your child including their results will be treated with the strictest confidentiality. No identifiable information will ever be released by the project. All children will be given a unique code which the research team will use instead of names. Data is securely stored and can be accessed by the research team only.

What do I need to do if I would like my child to take part in this study?

If you are happy for your child to take part in the measurements there is NOTHING you need to do. Your child will be included in the study and asked if they are happy to take part before it starts. They do not have to take part if they do not want to.



What do I need to do if I do not want my child to take part in this study?

Your son/daughter does not have to take part. If you DO NOT want your child to take part in the measurements detailed above please fill out the attached "*refusing consent/opt out form*" and return it to school.



Thank you for taking the time to read this information. If you have any questions please do not hesitate to get in touch. More detailed information can be accessed online from <http://bit.ly/1SVyoZS> or on request.

Contact Details of Researcher:

Sarah Taylor, Edge Hill University.
Email: sarah.taylor11@go.edgehill.ac.uk
Tel: 01695 657 344



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Refusing Consent/Opt Out Form

If you are happy for your child to take part in the measurements there is
nothing you need to do.

You should only return and complete the slip below if you **DO NOT** want your
child to participate in the measurements.



I **DO NOT** want my child (name)_____

to take part in the "Active Schools: Skelmersdale" project measurements.

Name of school_____

Name of parent/carers_____

Signature_____

Date_____

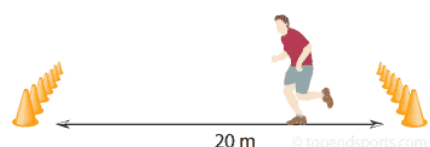



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- **Questionnaires** – Surveys will ask about the types of activities done and how often for the previous 7 days. Questions about children's thoughts on taking part in physical activity will also be included.
- **Measure of fitness** – 20m multi-stage shuttle run test. Children can stop whenever they wish but are encouraged to complete shuttle runs until they cannot keep pace with audible bleeps. 
- **Height, weight, waist circumference** – These measures will take place away from the rest of the group. No one but the researcher will see the results, they will not be made available to the school and will not be sent home, unless requested
- **Physical activity monitoring** – A small activity monitor will be handed out and children will be asked to wear this for 7 consecutive days. It is worn on the wrist like a watch and should only be removed during water based activities like swimming/showering. 
- **Focus groups** – Researchers will ask groups of children about their thoughts on the new ways in which their school has tried to increase physical activity, for example what they liked or enjoyed and what they didn't like. The audio of these conversations will be recorded but the children will remain anonymous and their opinions voiced will remain confidential.

All information about your child including their results will be treated with the strictest confidentiality. No identifiable information will ever be released by the project. All children will be given a unique code which the research team will use instead of names. Data is securely stored and can be accessed by the research team only.

Thank you for taking the time to read this information. If you have any questions please do not hesitate to get in touch. More detailed information can be accessed online from <http://bit.ly/1SVyoZS> or on request.

Contact Details of Researcher:
Sarah Taylor, Edge Hill University.
Email: sarah.taylor11@go.edgehill.ac.uk
Tel: 01695 657 344

If you agree for your son/daughter to take part, please complete and return the enclosed Parent/carers consent form.



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Parent/Carer Consent Form

Please tick the boxes if you agree with the statements below and return the form to school as soon as possible.

1. I have read and understood the information provided for the above study. ☐
2. I understand that my child can drop out of the study at any time, without giving a reason, and this will not affect my child's education in any way. ☐
3. I understand that any personal information collected about my child will be coded and kept confidential. ☐
4. I give consent for my child to take part in the above study. ☐

Name of child_____

DOB of child_____

Name of parent/carers_____

Home postcode_____

Signature_____

Date_____



Child Assent Form

Before you take part in the study we have to make sure that you are happy to take part.

Please circle Yes or No to the questions below and write your name if you want to take part.

Do you understand what this project is about? **Yes/No**

Have you asked all the questions you want? **Yes/No**

(If you have any questions ask now!)

Have you had your questions answered in a way you understand? **Yes/No**

Do you understand it's OK to stop taking part at any time? **Yes/No**

Are you happy to take part? **Yes/No**

If you want to take part, please write your name below

Your name_____

Your date of birth_____

Your home postcode_____



ACTIVE SCHOOLS: Skelmersdale

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Teacher Information Sheet

We would like to invite you to take part in an interview to discuss your perceptions and opinions in relation to the delivery of the physical activity intervention that has been running at your school.

Do I have to contribute?

No. It is up to you to decide whether or not you would like to take part in the interviews. Even after giving consent you are still free to withdraw from the study at any time without giving a reason. Testing will stop straight-away if you want to withdraw from the study.

What will happen?

The researcher will ask open ended questions allowing teachers to talk about different aspects of the intervention. The questions will cover topics including; implementing the intervention and the impact of the intervention as well as general discussions surrounding physical activity during the school day. An audio recording will be taken of the session. The interview should last between 15 – 30 minutes and will be conducted at a time most suitable for you on school grounds.

Confidentiality

All information about the school and yourself including the results and findings will be treated with the strictest confidence. No identifiable information will be released by the project, and all data is securely stored by project staff, and may be accessed by approved persons only.

If you have any questions do not hesitate to get in touch:

Sarah Taylor – sarah.taylor11@go.edgehill.ac.uk

Thank you for taking the time to read this.

Feel free to email me at any time.



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Teacher Consent Form

1. I can confirm that I have read all the information provided for the study and understand it. I have had the chance to consider the information and ask any questions of which have been answered satisfactorily. ☐
2. I understand that any personal information and all data collected within the interview will be randomly coded and kept confidential. ☐
3. I understand that data collected may be used in the final project report and additional research articles. ☐
4. I understand that my participation is voluntary and that I can withdraw from the study at any time, without giving a reason. ☐
5. I understand that everything discussed within the interview is confidential and therefore should not be discuss with anyone outside of the interview. ☐
6. I give consent to take part within the interview. ☐
7. I give consent for an audio recording to be taken within the interview. ☐

Name of School

Position at School.....

Name

Signature.....Date.....

Name of Researcher – Sarah Taylor

SignatureDate.....

Appendix 2: Accelerometer Instructions



ACTIVE SCHOOLS: SKELMERSDALE

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Activity Monitor Instructions and Diary

As part of the Active Schools: Skelmersdale project we would like to measure your physical activity levels. To measure your activity we'd like you to wear an activity monitor, like the one in the pictures below. It is worn on the wrist, is very light, and measures activity by sensing movements throughout the day.

How do I wear it?

- Wear the monitor on your non-dominant wrist, just like a watch (so if you're right handed, wear it on the left wrist, and if you're left handed, wear it on the right wrist).
- Adjust the wrist strap so that it is **tight enough so that the monitor does not move around your wrist when you are being active.**



When do I wear it?

- **Please wear the monitor at all times, during the day and night.**
- Please remove the monitor when taking a **shower**, having a **bath**, or **swimming**. Put the monitor back on straight after any of these activities.
- Please try and wear the monitor as much as possible. If you need to take it off **during the night** please make sure you **put it back on as soon as you get up** in the morning.
- If you do remove the monitor, please **use the table on the next page** to write down the times that you were not wearing it.

Activity Monitor Log Sheet

In the table below write down any times that you were not wearing the monitor for. The first row is an example for you to see how to fill it out.

Date:	Time periods when activity monitor was taken off	Reason activity monitor was taken off	Parental signature
Example: 08/09/17	8:00am-8:15am	Showering	<i>Mrs Smith</i>

When and how do I give the monitor back?

- The monitor will be collected from school on _____
- Afterwards we will give the school some anonymous feedback (you won't be identified) about the activity levels of the class.

If you have any questions you can contact the lead researcher Sarah.

(Sarah.Taylor11@go.edgehill.ac.uk) Thank you for taking part!

Appendix 3: School Survey used in Study 1

School Physical Activity Provision Survey

Background and General Questions

School Name.....

1. What is your current position at this school?

☐ Head Teacher ☐ Assistant Head Teacher

☐ Physical Education teacher/specialist ☐ Classroom Teacher

☐ Other (please specify).....

2. How long have you worked in this position at this school?

3. How many pupils are enrolled in your school?

4. Are you the school "Champion" for AS:Sk? Yes / No

5. Please identify if the following facilities are typically available for Physical Education (P.E.), playtime breaks, lunch break and for before-school and after-school physical activity programmes/initiatives at your school.

	P.E.	Playtime	Lunch	Before	After
a. Gymnasium	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b. Multipurpose room/ hall	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c. Grass field	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
d. MUGA (Multi-use games area)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
e. Playground	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
f. Regular classroom	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Instructions

1. Carefully read the questions and scoring descriptions for each item.
There are **20 questions in total**.
2. Circle the most appropriate number (0-3) for each question.

1.) Playtime breaks.

Not including lunchtime break, do pupils receive a total of at least 60 minutes of playtime breaks each school day?

3 = Yes.

2 = Playtime break opportunities for physical activity are no longer than 45 minutes altogether. **3 2 1 0**

1 = Playtime break opportunities for physical activity are no longer than 20 minutes altogether.

0 = Playtime breaks are not provided.

2.) Lunchtime breaks.

Not including time spent eating, on average do pupils receive at least 45 minutes of lunchtime break?

3 = Yes.

2 = Lunchtime break opportunities for physical activity are no longer than 30 minutes altogether. **3 2 1 0**

1 = Lunchtime break opportunities for physical activity are no longer than 15 minutes altogether.

0 = Lunchtime break only includes time spent eating.

3.) Frequency of breaks.

Including lunch, how many breaks do pupils receive each day? **3+ 2 1 0**

4.) Activity encouragement during breaks.

Do playground staff (including any teachers as well as playground supervisors) encourage pupils to be physically active during breaks?

3 = Yes, all staff supervising playground breaks encourage physical activity. **3 2 1 0**

2 = Most of our staff encourage physical activity.

1 = Some of our staff encourage physical activity.

0 = None of our staff encourage physical activity, their priority is the pupil's safety and behaviour.

5.) Organised activities at playtime breaks.

Are organised activity clubs/sports clubs provided for breaks?

3 = Yes, there are organised activities every day at break. **3 2 1 0**

2 = There are organised activities 3-4 days a week.

1 = There are organised activities 1-3 days a week.

0 = There are no organised activities provided for break time.

6.) Loose playground equipment. Is loose equipment available for pupils to play with during breaks? 3 = Yes, plenty of loose equipment is provided daily. 2 = There is some loose equipment provided daily. 1 = There is some loose equipment provided daily but it is not in good condition. 0 = There isn't any loose equipment provided.				
7.) Playtime break exemptions. Are playtime breaks withheld for academic/disciplinary reasons? 3 = Teachers are not permitted to withhold playtime breaks for either academic or disciplinary reasons. 2 = Teachers are permitted to withhold playtime breaks for academic reasons only. 1 = Teachers are permitted to withhold playtime breaks for disciplinary reasons only. 0 = Teachers are permitted to withhold playtime breaks for both academic and disciplinary reasons.				
8.) Playtime/lunchtime <u>outdoor</u> breaks during inclement weather. During inclement weather such as rain, what happens to outdoor playtime and lunchtime breaks? 3 = Pupils go outside whatever the weather. 2 = Pupils go outside unless the weather is very bad such as heavy rain, hail, ice, etc. 1 = If it is only light showers of rain pupils have the choice to go out or stay indoors. 0 = Pupils always stay indoors during inclement weather regardless of the severity.				
9.) Playtime/lunchtime <u>indoor</u> breaks during inclement weather. During inclement weather what happens when pupils are made to go indoors for their playtime and lunchtime breaks? 3 = Indoor play during inclement weather is in space large enough such as the hall to allow pupils to move about freely and physical activity equipment is made available. 2 = Indoor play during inclement weather is in space large enough such as the hall to allow pupils to move about freely. 1 = Indoor play during inclement weather is in the classroom but furniture is rearranged to allow pupils to move about freely. 0 = Indoor play during inclement weather is in the classroom doing seated activities such as chatting, reading, using computers, watching television, etc.				

10.) Physical Education (including P.E. and 'games' lessons) and non-curricular school sport.				
Do all pupils participate in curriculum P.E. <u>and</u> out of hours school sport for at least 180 minutes per week throughout the school year?				
3	2	1	0	
3 = Yes. 2 = 121-179 minutes per week. 1 = 60-120 minutes per week. 0 = Fewer than 60 minutes per week.				
11.) P.E.				
Do all pupils participate in curriculum P.E. for at least 120 minutes per week throughout the school year?				
3	2	1	0	
3 = Yes. 2 = 90-119 minutes per week. 1 = 60-89 minutes per week. 0 = Fewer than 60 minutes per week.				
12.) Activity during P.E.				
Are pupils moderately to vigorously active for at least 50% of the time during all P.E. classes? <i>Moderate-intensity physical activity requires a moderate amount of effort and noticeably accelerates the heart rate, for example brisk walking. Vigorous-intensity physical activity requires a large amount of effort and causes rapid breathing and a substantial increase in heart rate, for example running.</i>				
3	2	1	0	
3 = Yes, during most or all classes. 2 = During about half the classes. 1 = During fewer than half the classes. 0 = During none of the classes.				
13.) Frequency of P.E.				
3+	2	1	0	
How many P.E. classes per week do pupils receive?				
14.) P.E. space.				
How often is the delivery of P.E. compromised because of competing demands for P.E. space (e.g. for assemblies)?				
3	2	1	0	
3 = We always have sufficient space either indoors or outdoors for P.E. 2 = We sometimes do not have sufficient indoor space for P.E. (e.g., if there is bad weather). 1 = We have sufficient indoor space for P.E. but our space outdoors is limited. 0 = We always struggle to have sufficient space indoors and outdoors for P.E. lessons.				

15.) Teacher resources for P.E.

Are teachers provided with the following information and materials to assist in delivering quality P.E.?

- Goals, objectives, and expected outcomes for P.E.
- A written P.E. curriculum.
- A plan for assessing student performance.
- Internet resources.
- Guidance to assess or evaluate student performance in P.E.
- Learning activities that increase the amount of class time pupils are engaged in moderate-to vigorous physical activity.
- Learning activities that actively engage pupils with long-term physical medical, or cognitive disabilities in P.E.

3 2 1 0

3 = Yes, all teachers of P.E. are provided with at **least five** of the above materials.

2 = Teachers of P.E. are provided with **three to four** of the above materials.

1 = Teachers of P.E. are provided with **one or two** of the above these materials.

0 = Teachers of P.E. are **not** provided with these kinds of materials.

16.) P.E. exemptions.

Are P.E. lessons withheld for academic/disciplinary reasons?

3 = Teachers are **not** permitted to withhold P.E. for either academic or disciplinary reasons.

2 = Teachers are permitted to withhold P.E. breaks for academic reasons **only**. 3 2 1 0

1 = Teachers are permitted to withhold P.E. for disciplinary reasons **only**.

0 = Teachers are permitted to withhold P.E. for **both** academic and disciplinary reasons.

17.) Physical Activity opportunities before and after school.

Does your school offer opportunities for pupils to participate in physical activity before and after the school day, for example through organised activities (school sports, physical activity clubs, before-school physical activity), and/or provide access to facilities or equipment for physical activity during these periods.

3 2 1 0

3 = Yes, both before and after the school day.

2 = We offer before-school or after-school, but not both.

1 = We do not offer opportunities but there are plans to initiate this.

0 = We do not offer opportunities and there are no plans to initiate this.

18.) Active transport before and after school.

Does your school promote or support walking and cycling to school in the following ways?

- Designation of safe or preferred routes to school.
- Promotion activities such as participation in a walk to school week.
- Secure storage facilities for bikes and helmets.
- Instruction on walking/cycling safety provided to pupils.
- Promotion of safe routes to pupils, staff and parents via newsletters/website.
- Lollipop lady/man.
- Recording of number of pupils walking and or cycling to and from school.
- Creation and distribution of maps of school environment (paths, pedestrian crossings, roads, bike racks etc).

3 2 1 0

3 = Yes, our school uses six or more of these approaches.

2 = Our school uses three to five of these approaches.

1 = Our school uses one to two of these approaches.

0 = Our school does not use any of these approaches.

19.) Classroom Physical Activity.

Are pupils given opportunities to participate in physical activity breaks in classrooms, outside of P.E., recess, and class transition periods? These are short breaks that occur in the academic classroom, allowing pupils to engage in physical activity as a break from academic tasks.

3 2 1 0

3 = Yes, on all days during a typical school week.

2 = On most days during a typical school week.

1 = On some days during a typical school week.

0 = No, we do not provide pupils with opportunities to participate in physical activity breaks in classrooms.

20.) Sitting and standing in the classroom.

Are pupils given opportunities to stand in classrooms?

3 = Yes, there is physical provision for standing during lessons, for example sit-stand desks.

2 = Some classroom lessons are taught with pupils standing rather than sitting.

3 2 1 0

1 = Pupils are allowed to choose whether to sit or stand during classroom lessons.

0 = Pupils sit for the majority of classroom lessons unless doing activities that sometimes require them to stand, for example art.

Date of completion.....

Appendix 4: Study 2 child semi-structured interview guide. AB and BTM intervention.

We want to listen to some of your thoughts and feelings on the activities you've been doing in school recently, what everyone says is all really important to us which is why we have to record it so we don't miss anything. We won't know it's you speaking, it'll just be voices we hear. The most important thing is that only 1 person talks at a time, so no talking over each other.

1. Can you tell me what has been different about your school day over the past few weeks?
 - What activities have you been doing every day?
 - When have you been taking part in the classroom activities/videos – have they been at different times or the same time every day? If at different times which time did you prefer?
 - Who decided what the activity cards/video would be?
 - How many active breaks would you like there to be in your school day?
2. If somebody new was to join your class and you had to tell them about the active breaks/videos you've been doing how would you describe them?
3. Have you talked to anyone about the active breaks/videos you have been having in school? – Friends on the playground, other teachers in school, mum/dad/sister/brother at home?
 - What have you told them?
4. Have you enjoyed taking part in the activity breaks/videos?
 - What did you like about them – what did you not like about them?
 - Enough variety with the activity cards/videos?
 - Any movements too hard?

- Did you have a favourite specific activity card/video – why did you enjoy that one?
 - Did you have a least favourite activity card/video – what didn't you like about it?
5. How did your body feel after taking part in the activities/videos?
- Did you feel different – was this a good or bad different?
6. What was it like going back to sitting down for normal classroom learning (reading and writing) after the active breaks/videos?
- What is it like going to class and sitting down to learn without having an active break/a video?
7. Do you think the taking part in the activity breaks has got in the way of your classroom learning at all?
8. How would you feel if your teacher decided to stop having active breaks in class/videos in the hall?
9. Would you like there to be more activity during your school day?
- Where and when would you like there to be more activity during the school day?
 - Why would you like there to be more activity/why would you not like there to be more activity during the school day?

Appendix 5: Study 2 child semi-structured interview guide. Playground intervention.

We want to listen to some of your thoughts and feelings on the activities you've been doing in school recently, what everyone says is all really important to us which is why we have to record it so we don't miss anything. We won't know it's you speaking, it'll just be voices we hear. The most important thing is that only 1 person talks at a time, so no talking over each other.

10. Can you tell me what activities you have been doing at break and lunch time over the past few weeks?

- What activities do you enjoy doing most?
- Why do you enjoy them – what makes them enjoyable – what do you like about them?

11. Has anyone taken part in the activity cards at break and lunch time over the past few weeks?

- Did you enjoy them – what did you enjoy about them/what did you not like about them
- Do you have a favourite activity card which you have taken part in?
- How often did you take part in the activity cards – can you remember who has decided to start an activity card?

12. Can anyone tell me anything you have learnt from the 'fact cards'?

13. For those who haven't took part in the cards - what were the reasons for not taking part?

14. Has anyone received an activity sticker during break or lunch time?

- What did you receive the sticker for?
- When wearing your sticker did anyone ask you about it – what did you tell them?

15. Has anyone lead an activity card and got other children to take part?
- How did it go – how did you feel leading the activity?
16. What do the teachers on the playground do at break and lunch time?
- Have any teachers taken part in the activity cards?
 - Do you think teachers taking part has made/would make a difference – how would it make a difference?
17. Can you think of any physical activities that you would like to take part in during break or lunch time?
18. After lunch time how do you feel going back to class and sitting down to learn and listen?

**Appendix 6: Study 2 teacher semi-structured
interview guide. AB and BTM intervention.**

1. Can you provide some general detail on how you have been implementing the active breaks/Videos?
 - Particular time of the day – *if so, why then?*
 - How many times – *do you think this amount could be increased?*
 - How long have they been (minutes) – *If actual activities/exercises lasted 5 minutes how much time not engaged in teaching/learning would that be in total?*
 - Where have the videos been taking place – *have you ever struggled for space to do them in day?*
2. Can you describe how your first active break went?
 - What was the initial reaction of the children to the activities/videos?
 - How long did it take for yourself and the class to adapt?
3. How much planning was required
 - Any changes to classroom needed?
 - Room bookings?
 - Did you plan when they would happen or was it as and when you thought they would be beneficial?
4. Are there any barriers which have prevented you from implementing the active breaks/videos on certain days?
 - Can you think of any days when they were not used and why that was?
5. Were there any activity cards/videos which were unsuitable and are no longer used?
 - Reasons why they're no longer used?

6. Do you think you would be able to sustain the active breaks/videos consistently across a whole school year?
 - Are there any additional resources you would need to be able to do this – *was there enough activity cards/videos for a whole year?*
 - Do you think the children would engage for a full school year, do you think there is a novelty aspect which would wear off?
 - Would a financial cost to access additional videos that were continuously updated change your view of continuing to use them?
7. Do you think the children have enjoyed the active breaks?
 - If yes/no what makes you think that?
 - Was there a favourite activity/video?
8. Do you think you could have more year groups/whole school involved in the videos consistently across a school year ?
 - How much planning would that require?
 - Would there be enough space, how often would the hall be needed?
9. Do you think it has influenced behaviour in any way – positive or negative?
 - What was the transition to learning activities afterwards like?
 - Was there any behavioural issues during the activities/videos?
10. Has it positively or negatively impacted your day as a teacher in any way
 - How has it influenced your available teaching time during the school day?
11. How high or low would you prioritise physical activity during the school day
 - Has this 4 week trial changed this opinion?
 - Would you be willing to try other ways of incorporating physical activity during the school day?

Appendix 7: Study 2 teacher semi-structured interview guide. Playground intervention.

1. Did you learn anything from the session you attended – what were the main messages you took away from the session?
 - How did you view your role on the playground after the training session?
2. Can you provide some general detail on how you have been using the activity cards?
 - Was it easy or difficult to set them up?
 - What children have been taking part – particular group/year?
3. Have there been any issues with the activity cards being used?
 - Behavioural issues
 - Space/equipment
 - Too difficult or too easy
4. How were the activity cards introduced to the children?
 - Initial reaction of the children?
 - Did this initial reaction change?
5. How much teacher/adult involvement is needed for the activity card games?
 - Have you took part in any of the activities?
6. Were there any activity cards which were unsuitable and are no longer used – if so why were they unsuitable?
7. Are there any barriers which have prevented the activity card games from taking place on the playground?
 - Do you think any of these barriers could be addressed?
8. Do you think the activity card games could consistently take place across a whole school year?

- Are there any additional resources you would need to be able to do this –*enough activity cards*?
- Do you think the children would engage for a full school year, do you think there is a novelty aspect which would wear off?

9. How have you distributed the activity stickers?

- What has been the children's reaction to the stickers?
- Are they a useful tool for promoting activity?

10. Overall what are the main barriers to getting children more active during break times?

11. Is there anything you think can think of that could help you to get children more active on the playground – relating to equipment/space/policies/rules for example?

Appendix 8: Study 4 semi-structured WDST guide

1. Name Badge

2. Pictures of each intervention

You might have done some more than others or you might not be able to remember doing some at all.

3. Favourite on your post it note

On your post-it note please write down which one if these has been your favourite to do or which one you have enjoyed doing most in school the past few weeks. Don't worry about what everyone else is writing down just write down which one you think has been your favourite, if you have really liked more than one and can't pick one favourite down you can write down more than one.

Pick out child – So why did you write that one down as your favourite? What do you enjoy about it?

Did anyone else write that one down as their favourite? Other child with same favourite – You also wrote that down as your favourite, why is that your favourite too?

General questions for the whole group

- How do you feel when your teacher says you are going to do it?
- How do you feel after it?
- What does your teacher do during them? – What is it like taking part with your teacher?
- Who else are you with during the activities?
- Do you feel different doing them now compared to when you first started? – Can you think of how your body feels different?
- Were the activities hard or easy to complete? – What was it about the exercises which made them hard/easy?
- Was the activity enjoyable? – What did you enjoy about it? Was there anything you did not like about them?
- How often are you doing them?

- Can you think of any reasons why you haven't done them in the school day?

Pick out another child who wrote down a different favourite.

Now I want you to draw a picture of you doing your favourite activity we've talked about. So the first page is like the front of a book and then on the second page you can write down what you are doing and what you like about it. Throughout the drawing activity separately engage children in conversations for them to articulate what they were drawing and why.

Once all completed drawing, talk through the picture to the group.

Appendix 9: Study 4 teacher semi-structured interview guide

Situation	<p>How long have you been at this school?</p> <p>Do you think that your position has had an influence on implementing the activities – willingness to try new things as an inexperienced or experienced member of staff?</p>
Knowledge/Source of Knowledge	<p>What were you initial thoughts towards it? – Positive/negative why?</p> <p>Have these initial thoughts changed after implementing the strategies with your class?</p>
Intentions and plans	<p>Did you set a plan for how to use and implement the activities?</p> <p>Did your plan and intentions change? Did you do more or less than you thought/planned?</p>
Talk through each component	
Active Classroom Breaks	<p>How have you been using them, when are they used?</p> <p>How often does this happen? Has this been consistent across the weeks?</p> <p>Do you think the activities are suitable for use in your classroom? What makes them suitable/unsuitable?</p> <p>Are the resources sufficient enough?</p> <p>Do you think they are sufficient for getting heart rate increased?</p> <p>What is the reaction of the children towards them?</p> <p>Do they have any influence on the children?</p> <p>What influence does it have on the flow of lessons?</p> <p>What is the transitions to sitting down and listening afterwards like?</p>
Daily Mile/100 MC	<p>Is this done at the same time across the week or different times?</p>

	<p>How often have the children been able to do this during a week?</p> <p>Is there anything which has prevented you from being unable to do this in general or to do it more?</p> <p>How often has the weather stopped you?</p> <p>How much time does it take to implement?</p> <p>Would you consider this to be a significant amount of time where you can see the impact on amount of content covered?</p> <p>What are the children's perceptions towards doing it?</p> <p>Children's motivation towards engagement?</p> <p>Do you think the children need incentives?</p>
Born To Move	<p>Did you manage to do any of these videos with the children?</p> <p>How consistent was this across the weeks?</p> <p>What times of the day/week were they implemented?</p> <p>How accessible is the hall?</p> <p>Does having to get to the hall have an impact on feasibility?</p> <p>Do you think the children enjoy the videos? What do they like/dislike about them?</p>
Physical Activity Homework	<p>Did you manage to talk about or set any physical activity challenges for homework?</p> <p>Did the children track any physical activity homework with their recording sheet?</p> <p>What are your thoughts on trying to target this after school period? Is it something you think the school or yourself as a teacher could have an influence on?</p>

Additional topic points

Social Influences	<p>Did you feel supported by other teachers and the head teacher to implement the physical activities with your class?</p> <p>Did you feel that being the only class to implement the activities had an impact on you being able to do so?</p>
Identity	<p>Did you feel as though you had ownership of what you were doing with the activities?</p> <p>Did it feel like something you were implementing because you were told to so?</p> <p>Were you able to adapt or change them to suit your class?</p>
Beliefs	<p>Did you feel confident enough to be able to implement the activities?</p>
Emotions	<p>What are your overall thoughts towards physical activity in the school day?</p>
Recommendations	<p>What would your recommendations be to another teacher if they were planning on implementing the physical activity strategies similar to you with their class?</p>

Appendix 10: Example coding on transcription (Study 4)

Statements of interest	Codes
<p>“My biggest initial concern would have been the time, and how that influences the impact on the timetable, because obviously we've a lot to fit in.”</p>	<ul style="list-style-type: none"> • Covering the curriculum with the time available. • Initial reaction pre-implementation
<p>“I also thought it could be a good thing for those children who perhaps don't do as much physical exercise out of school, mainly because it would get them thinking, get them active a bit more, and physically, being really, I think, sort of trying to like, might open their minds a little bit more so they'll engage with their learning better.”</p>	<ul style="list-style-type: none"> • Initial reaction pre-implementation • Implications for health • Implications for learning • Pre-existing knowledge/understanding of PA benefits
<p><i>100 MC</i></p> <p>“I'd come up with the plan initially that in the mile run, I want to do it on two days, or three days.”</p> <p>“I've still kept it to two days.”</p>	<ul style="list-style-type: none"> • Frequency of implementation • Teacher set a plan • Routine
<p><i>100 MC</i></p> <p>“On one day, because they go swimming and we walk to swimming, I wasn't going to do a mile run on top because it is quite a lot of exercise for them.”</p>	<ul style="list-style-type: none"> • Competing PA already in the timetable
<p><i>ABs</i></p> <p>“The exercises in the classroom that you can do that gives them a two-minute break, it's when I have the longer sessions, either in a morning or in an afternoon, and they need that sort of change, just a transition time, really.”</p> <p>“It's more that would be a transition within the lesson anyway. So we might move from English to guided reading or something like that, they finish their English, we do the exercise and I'll say, "Right, move to your</p>	<ul style="list-style-type: none"> • Implementation techniques • Fit with timetable • Break from learning • Transition or split classroom time up

guided reading places", and do it that way. That's what happens. So again, it would be as part of the transition.	
<p><i>BTM Videos</i></p> <p>"They do it in the hall, and twice a week, the whole school do Wake and Shake, on a Tuesday and a Friday. Now we do an extra one after that session. They're already there. It's just set up ready to go, and we just do an extra one."</p> <p>"I think it was already started. It was already there. It's something that they've always done as a school here."</p>	<ul style="list-style-type: none"> • Implementation techniques • Whole school approach • Following school policies • Routine • Consistency
<p><i>BTM Videos</i></p> <p>"They do it in the hall, and twice a week, the whole school do Wake and Shake, on a Tuesday and a Friday."</p>	<ul style="list-style-type: none"> • Frequency • Specific times/Routine
<p><i>BTM Videos</i></p> <p>"They quite like to choose their favourite sometimes. So that is a bit of an incentive I use with them, that they can choose if they reach certain milestones or whatever."</p>	<ul style="list-style-type: none"> • Implementation techniques • Incentives for children to engage • Teacher adaptation to suit the children
<p>"I think sometimes, if we're doing something and we have to be somewhere, it doesn't always happen then, or if like something additional is going on, and we have to shuffle the timetable a little bit. Sometimes it doesn't always happen."</p>	<ul style="list-style-type: none"> • General barriers • Time within the timetable • Dynamic school environment, no days the same
<p><i>BTM Videos</i></p> <p>"if they all want a drink, and because it's the start of the day when you need to get everything sorted, it can be a bit tumultuous in that respect."</p>	<ul style="list-style-type: none"> • Transitions after PA • Time as a barrier • Children can slow the process down
<p>"It doesn't take them long now they've got into the sort of routine and the swing of doing it."</p>	<ul style="list-style-type: none"> • Becomes part of the routine

	<ul style="list-style-type: none"> • Time needed for children to adapt and get used to PA
<p><i>BTM Videos</i></p> <p>"If they have had it, they're less fidgety, they'd sit for longer doing their work, which is what I'm trying to build up their stamina to work. So of course if they've got more concentration, then that's going to help with that process."</p>	<ul style="list-style-type: none"> • +ive Behaviour after engaging in PA
<p><i>BTM Videos</i></p> <p>"Yes, they do, because they do say, "Are we doing this, Miss? Are we doing that? Can we do this one?" So if you get asked those questions, you know they must like it. They wouldn't ask me if they didn't."</p>	<ul style="list-style-type: none"> • +ive Reaction from the children • Children like and enjoy the PA
<p><i>ABs</i></p> <p>"Logistically, for some, it can't be done with twenty-five in the room. So it's finding the ones that are practical to do."</p> <p>"It is tight for space. I try and arrange the tables in groups, rather than rows, because I think it helps their learning more, and I can get round better to see, but logistically, it doesn't mean that you are... It can be quite difficult, but then again, they're very good at keeping away from furniture, or just moving things away."</p>	<ul style="list-style-type: none"> • Barrier of space • Classroom logistics • Space
<p><i>ABs</i></p> <p>"They choose which exercise, and sometimes I might choose a child who's won, say, writer of the week, or who's done something, so got so many excellents."</p>	<ul style="list-style-type: none"> • Implementation techniques • Incentives for children to engage • Adaptations for engagement
<p><i>ABs</i></p> <p>"Just randomly choose like a lucky lotto child, and I just pull them out and say, "Ooh, you're choosing which exercises". So they'll choose which floor exercises we're doing today."</p>	<ul style="list-style-type: none"> • Implementation techniques • Child involvement • Child choice

	<ul style="list-style-type: none"> • Teacher adaptation to suit the children
<p><i>ABs</i></p> <p>"Across the week, it tends to be on average about four."</p>	<ul style="list-style-type: none"> • Frequency of implementation
<p><i>ABs</i></p> <p>"Sometimes if they're keen, they're on with their work, I don't stop them, because obviously that would then...well, usually they're just focussed on their work, but sometimes when they get to a point, and you can tell they've just reached that point of, "I need to do something different", then we do it then."</p>	<ul style="list-style-type: none"> • Implementation techniques • Flexibility to use as and when needed • Different times each day
<p><i>ABs</i></p> <p>"They seem to settle down back on, once they've had a drink again, they settle back down onto task and they seem to be more settled and keen to start their work."</p>	<ul style="list-style-type: none"> • +ive Behaviour after engaging in PA • Readiness to learn
<p><i>100 MC</i></p> <p>"On a day when I have got another member of staff, then we'll happily do the mile run, because they can watch them on the playground, I can watch the other, and we can also deal with any injuries in between, should they arise, basically."</p>	<ul style="list-style-type: none"> • Staffing barriers • Routine, PA on a specific day because of practicalities
<p><i>100 MC</i></p> <p>"Any that haven't wanted to run, we've tried to do it where we encourage them to do a brisk walk or skip."</p>	<ul style="list-style-type: none"> • Implementation techniques • Encouragement for children • Adaptation to engage certain children
<p><i>100 MC</i></p> <p>"You've got some at the bottom who, it's not their cup of tea, really, but they will try, they'll do it, they persevere, and again, it's one of those where they get into groups and, "Right, come on, we'll do this"."</p> <p>"With friends, it helps."</p>	<ul style="list-style-type: none"> • Peer influence • Engagement with friends
<i>100 MC</i>	<ul style="list-style-type: none"> • Amount of time needed

<p>"It can get to about half an hour."</p> <p>"Because we do the fifteen-minute run, but of course we've to change into trainers and, you know, give them a drink and get them to count the counters. So they are getting there. Now, for some of them, the recovery's getting quicker. Yes, they're coming in breathless. They've obviously done the exercise, but their recovery is getting quicker, whereas others do take that little bit longer and sit there a bit, you know."</p>	<ul style="list-style-type: none"> • Additional organisational time outside of PA engagement
<p><i>100 MC</i></p> <p>"I'm trying to get it down so it's more like twenty minutes, including getting changed. So I'm finding ways where it might be, "Right, we're getting ready. Go and get your trainers, get them ready. Whilst I'm doing the register, put your trainers on". That sort of thing. So it's little time-saving things that I could perhaps do."</p>	<ul style="list-style-type: none"> • Strategies to reduce time • Adapting as implementation increases
<p><i>100 MC</i></p> <p>"That's a significant part for them. Because once I did go out, I forgot the tub. I had it in my hand, turned round to do something, and they went, "Miss, where are my counters?" And I was like, "OK, hang on". So I sent a child in for them, and came back, and they were, "Miss, you owe me two. Miss, you owe me this". So I think if that wasn't there, it would dis-incentivise it for them. They really wouldn't like it. The incentive is, how many counters have I got at the end of it, and have I got my next mile?"</p>	<ul style="list-style-type: none"> • Importance of rewards • Importance of incentives
<p><i>PA homework</i></p> <p>"Now they liked doing it initially, but then they found after about four or five weeks, because it was repetitive, the same thing, they thought, "Oh, Miss, it was getting a bit of a tedious task", rather than an, "I want to" task, "I want to do it", and the number of them completing it dwindled."</p>	<ul style="list-style-type: none"> • Decrease in interest over time • -ive Repetitiveness
<p><i>PA homework</i></p>	<ul style="list-style-type: none"> • Family engagement at home – social support

<p>""Oh, I'm doing this with my Granddad". So they might have been doing it with different people at home, not just... They were like down to Granddad's to help them garden and that sort of thing."</p> <p>"When I looked at some of the comments, it was the social side they liked, or they liked that sort of thing."</p>	
<p><i>PA homework</i></p> <p>"I think it needs a bit less sort of on the paperwork. It might be worth giving them a calendar, just with the days on, a blank one, like put the days on and the dates, and then get them to write what exercise they've done on that particular day, so they don't have to mass-record, but it does mean they can, if they've done something different they wouldn't usually do, say like gardening or trampolining, or if they've been to a friend's party, that's the same idea, so they see that they're doing different exercises at different times."</p>	<ul style="list-style-type: none"> • -ive Repetitiveness • Potential alternative approaches
<p>"It had to work for, really, us. If it isn't working, it's no point us trying, because it's not going to help the children a lot, whereas now, because we can adapt it and they tell me what they like and don't like and things like that, they can do it from there, yes."</p> <p>"I think, really, to find a time that suits you and do it for the length of time that suits the children."</p> <p>"I think it's good that I've been able to, like I said, adapt it, but at the same time, take the experience further with them."</p>	<ul style="list-style-type: none"> • Flexibility • Ability to adapt • Make it your own • Changes to suit the needs of the class/children • Input of children reporting what they like and do not like
<p>"Implement it into the routines, and make it work that way."</p> <p>"It has become part of the routine."</p>	<ul style="list-style-type: none"> • Routine
<p>"See that some children, whilst in PE they might struggle with some moves and different things, in this it's really brought them out, it's really given them that sort of incentive."</p>	<ul style="list-style-type: none"> • Non 'sporty' children engaging +ive • Child incentives for engagement
<p>"Build it up gradually really, and sort of implement it a little bit at a time sort of thing."</p>	<ul style="list-style-type: none"> • Start slow, staggered implementation

	<ul style="list-style-type: none">• Flexibility to implement when suited the teacher
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Appendix 11: Example Intervention Resources

MARCHING IN PLACE



ACTIVE SCHOOLS:
Skelmersdale

MARCHING IN PLACE

DIRECTIONS

1. Stand up tall
2. March in place
3. Lift your arms and knees up high
4. March as quickly as you can so that your heart beat is raised
5. Continue for 30 seconds



ACTIVE SCHOOLS:
Skelmersdale

REACH & SQUAT



ACTIVE SCHOOLS:
SKELMERSDALE

REACH & SQUAT

DIRECTIONS

1. Have your feet shoulder width apart
2. Hold your arms in the air with your hands together, palms facing each other
3. Using your arms, reach down like you are chopping some wood with your knees bent
4. Then jump in the air and lift your arms back up before repeating as quickly as you can
5. Continue for 30 seconds



ACTIVE SCHOOLS:
SKELMERSDALE

TOPSY TURVY

Group Size

- 4 or more

Equipment Needed

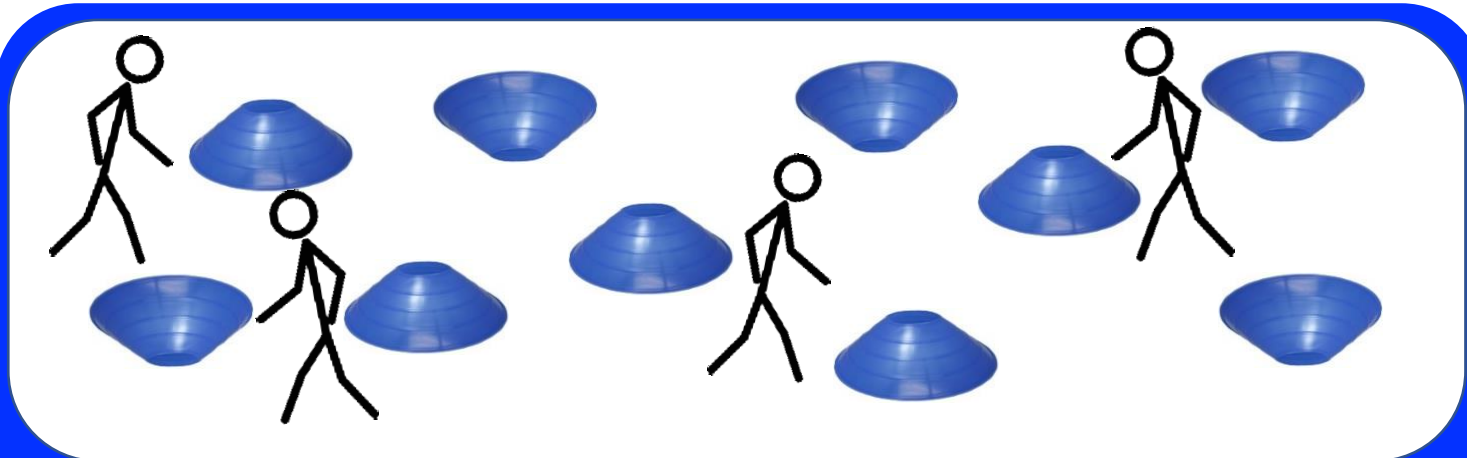
- Cones

Safety Points

- Be careful when you are bending down to turn cones, especially if others are close by

Easier – Walking only

Harder – Uneven groups



Instructions

- Have 2 equal teams and name one team the 'topsy' and the other team the 'turvy'.
- Set the cones out, with half of them facing up normally and the other half upside down.
- When someone shouts go, the topsy team try to turn all the cones facing up whilst the turvy team try to turn all the cones upside down.
- Play for a set amount of time and count how many cones are facing up and down to see which team wins.



BEANBAG TAG

Group Size

- 3 or more

Equipment Needed

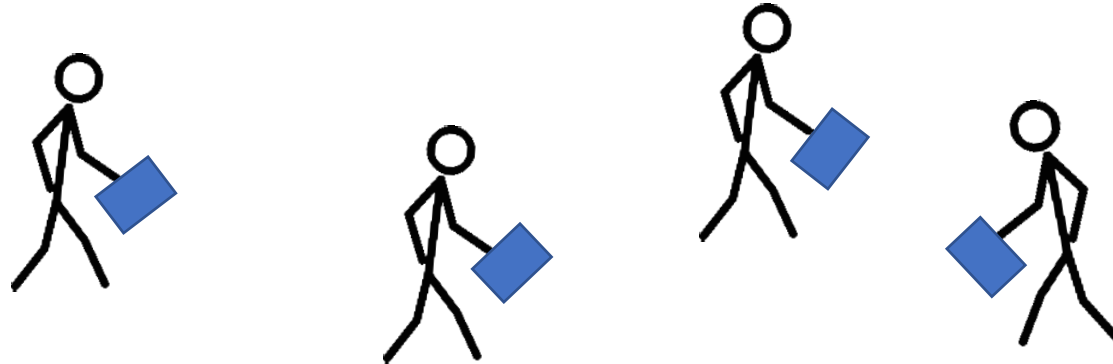
- 1 beanbag per player

Safety Points

- Underarm throw only

Easier – Tag any part of the body

Harder – Longer activities when tagged, e.g. 20 jumping jacks



Instructions

- Each player starts with a beanbag.
- Everyone is 'it'.
- The object of the game is to tag other by hitting their feet/shoes with your beanbag using an underarm throw whilst avoiding being tagged by the other players.
- If you are tagged with a beanbag you must perform an activity before being allowed back in the game, for example 10 jumping jacks, 10 squats, 10 seconds of high knees etc.



ACTIVE SCHOOLS:
SKELMERSDALE

Edge Hill
University

West
Lancashire
School Sport Partnership

Playground activity cards – Chapter 6 (Study 3)

ACTIVE SCHOOLS:
SKELMERSDALE

The game of Physical Activity & Health

PLAYGROUND HIIT GAME

HIGH INTENSITY INTERVAL TRAINING

Hi!

LET'S GO!



GAME NUMBER 4

ACTIVE SCHOOLS:
SKELMERSDALE

ACTIVITY 1

AWESOME!

Tuck Jumps

Stand with your feet apart and arms out in front of you. Lower into a squat and explode up in the air touching the palms of your hands with your knees.

Repeat this jump 15 times.



GAME NUMBER 4


ACTIVE SCHOOLS:
SKELMERSDALE

How's it Goin' ACTIVITY 2

Power Knees

Stand with your feet wide apart. Raise your arms to the right above your head. Drive your left knee up whilst bringing your hands down so that they meet.

Repeat this 15 times on each leg.



GAME NUMBER 4

ACTIVE SCHOOLS:
SKELMERSDALE

YOU GOT THIS ACTIVITY 3


Ground Touches

Have your feet shoulder width apart. Squat down and touch the floor with your fingertips whilst keeping your back straight.


Repeat this 10 times with each hand.




Physical activity homework



WEST LANCASHIRE
SPORT PARTNERSHIP
EDUCATION • HEALTH • ACTIVE LIVING



ACTIVE SCHOOLS:
Skelmersdale



Edge Hill University

ACTIVITY HOMEWORK CHALLENGES

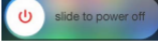
BORN TO MOVE

Born To Move Videos

Born to Move videos by fitness company Les Mills are made for children to follow instructor led moves to music. They are fun, jam-packed videos!

1 Type the following link into a web browser on a device (laptop/tablet) and open a free video which is for 8-12 year olds. Find some space that is safe from any obstacles and follow a video.

https://www.lesmillsondemand.com/en_uk/videos/kids-free.html?c=&p=1




15 minute power down

Playing on electronic devices such as iPads or other tablets, phones and video games or watching TV can be fun but sitting down for long periods of time is bad for our health.

2 Power down the device you play on 15 minutes earlier than you normally would. Replace this time you would normally spend sitting still with some helpful chores around the house! You could help wash the dishes, load the dishwasher, brush the kitchen floor, Hoover the living room floor or tidy your room. If you don't play on any electronic devices, you can still do an extra 15 minutes of chores!

Your screen time should be no more than 2 hours per day, try and get it below this time period.



Active adverts

We all have a favourite TV programme that we enjoy watching at an evening.

3 Instead of sitting down for the whole of the programme, make the advert breaks active! As soon as the adverts start stand up and get active until your programme comes back on. You could do star jumps, jogging/sprinting on the spot, marching on the spot, high knees, heel flicks. Don't stop moving until your programme starts again. If there are no adverts, make sure you do 2 minutes of moving before it starts and after it finishes.

4

Family walk before or after tea time

It could be a walk to the park or a simple walk round the block. Even if you have walked home from school, this extra bit of walking will also be beneficial for your health.

You must walk with an adult, try to get as many of your family involved as possible and make it a regular activity which you do together.

5

Kids Vs Adults

Set some simple challenges which you can do at home and see if you and your sisters/brothers/friends can beat the adult at home with you.

Here are some ideas; (1) Watch the clock or use a watch to see who can sprint or do fast feet on the spot for the longest. (2) Choose a start point and end point in your house and design a route on how to get from each point, see who can do it the quickest you could make it harder by hopping the route on one leg only. (3) The minute challenge, chose an activity to do for a minute, it could be squats, lunges, sit ups or something similar, see who can do the most in a minute. (4) Collect a pile of books and mark a start and finish point in a straight line. Balance 1 book at a time on your head and carefully walk to the finish line. If you drop the book you must go back to the start. See who can get all the books to the finish line the quickest. (5) Who can jump the furthest? You might want to try this in the garden for more space. Change it up and try jumping off one leg only or jumping with a two-step run.

Can you think of any other games you can try and beat the adults at?

6

Gardening

Go into your garden and find a job which you could help do. If you do not have a garden you could ask a neighbour or tidy in front of your house.

What jobs need doing? You could collect rubbish, brush up leaves, water the plants, or pull weeds.

7

Dance

What is your favourite song at the moment? Is it in the charts or is it an older song? Whatever it is play it out loud and have a dance to it.

Don't worry if your dance moves aren't perfect, just move about and have fun to your favourite song!

8

Evening buzz word

As soon as you get home from school think of a buzz word. Try and think of word that is said a lot in your family, for example, please or thank you.

Every time somebody in your house says the buzz word everybody must do an activity together. The activity could be 20 star jumps, 20 squats, marching on the spot for 30 seconds.

9

Exercise Dice

Find some paper, cut out the shape shown and fold it so it makes a dice, use some celotape to keep it together. Always ask for help from an adult when using scissors.


On the first dice write 6 different numbers. On the other dice write 6 different exercises. Take it in turns to roll the dice and complete the number of exercises shown when they land. Roll the dice at least 5 times each!

10

Heart rate

Any activity that raises your heart rate above resting value can be beneficial to your overall health.

Sit still for 1 minute then find your pulse on your wrist below your thumb, using your index and third fingers of your other hand. When you find your pulse count the number of beats in 15 seconds. This number of beats multiplied by 4 is your resting heart rate. Now your challenge is to increase this resting heart rate. Go for a walk around the house, take your heart rate again, how much has it increased? Can you get it to go higher by doing something harder than walking such as running outside?



Appendix 12: Associated Publications



Article

Predictors of Segmented School Day Physical Activity and Sedentary Time in Children from a Northwest England Low-Income Community

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Abstract: Background: Schools have been identified as important settings for health promotion through physical activity participation, particularly as children are insufficiently active for health. The aim of this study was to investigate the child and school-level influences on children's physical activity levels and sedentary time during school hours in a sample of children from a low-income community; Methods: One hundred and eighty-six children (110 boys) aged 9–10 years wore accelerometers for 7 days, with 169 meeting the inclusion criteria of 16 h·day^{−1} for a minimum of three week days. Multilevel prediction models were constructed to identify significant predictors of sedentary time, light, and moderate to vigorous physical activity during school hour segments. Child-level predictors (sex, weight status, maturity offset, cardiorespiratory fitness, physical activity self-efficacy, physical activity enjoyment) and school-level predictors (number on roll, playground area, provision score) were entered into the models; Results: Maturity offset, fitness, weight status, waist circumference-to-height ratio, sedentary time, moderate to vigorous physical activity, number of children on roll and playground area significantly predicted physical activity and sedentary time; Conclusions: Research should move towards considering context-specific physical activity and its correlates to better inform intervention strategies.

Keywords: physical activity; schools; children; accelerometer

1. Introduction

Physical activity (PA) is associated with numerous health benefits in school-aged children [1]. Beneficial effects relate to cardiovascular [2] and cardiometabolic risk factors [3], and mental health [4]. Internationally it is recommended that children engage in moderate-to-vigorous PA (MVPA) every day for at least 60 min [5–7]. Report cards on the overall PA of children and youth across 38 countries using self-reported data from a number of surveys have specified that levels are low [8]. Grades of D- were given to England, Australia, Canada and USA, indicating that less than 30% of children in these

countries are sufficiently active [8]. Moreover, data from the International Children's Accelerometry Database (ICAD) [9] reveal that children aged 4–18 years engage in MVPA for an average of 30 min per day [10], and that after the age of 5 years there is an average decrease of 4.2% in total PA with each additional year of age, due to lower levels of light-intensity PA (LPA) and also a progressive increase in the volume of sedentary time (ST) [9]. Excessive time spent sedentary is positively associated with markers of adiposity and cardiometabolic risk [11]. International PA guidelines make further recommendations in regards to limiting the amount of ST children accrue [5,6,12]. Current evidence suggests that screen time has a bigger impact on health compared with overall ST [13]. For example, television viewing has been shown to demonstrate a strong relationship with overweight/obesity and inverse relationships with fitness [14]. High levels of time engaging in screen-based ST have also been linked to lower self-esteem in youth [15].

This evidence linking low PA and high ST to adverse health outcomes warrants interventions which promote PA participation and ST reduction in children. Within the school setting there are PA opportunities during discretionary periods between lessons and at break times/recess, through classroom activities, during structured PA periods such as physical education (PE) lessons, and through extra-curricular opportunities before and after the formal school day [16]. Investigations have indicated that PA during school recess can contribute towards up to 40% of a child's recommended daily PA [17], whilst PE has been shown to play a substantial role in providing PA for children as they are more active on days with PE than without [18]. Thus, schools have been identified as a key environment for child PA promotion. Over 95% of youth and therefore the full socio-economic spectrum of the paediatric population can be reached and engaged regardless of individual circumstances [19–21]. Lower socioeconomic status (SES) home environments typically provide more opportunities for ST and fewer for PA [22]. It has been argued that more positive attitudes towards the value of PA and healthy lifestyles are evident in families with a higher SES, which may be reflected by high SES children attaching greater importance to PA participation for health benefits, relative to perceptions from a comparable group of low SES children [23]. This trend was observed by Drenowatz et al. [24], through the use of household income as an indicator of SES, and steps per day to assess free-living PA, with lower PA levels and more time in sedentary behaviours found among low SES children. However, use of different methods of measuring PA and SES suggest that associations reported between SES and children's PA are equivocal [25]. School environments provide the opportunity for SES influence to be minimised due to all children attending regardless of individual circumstances. In order to develop effective PA interventions within schools it is important to understand all factors which influence participation [26]. PA and sedentary behaviours are complex and their occurrence varies within different domains. Youth PA and ST correlates are represented at the individual, interpersonal, organisational, and system levels [27]. In addition to SES, correlates consistently associated with PA in children include sex, age, ethnicity, perceived competence, and perceived barriers [28]. Whilst it is useful to understand what influences children's habitual PA and ST, these may not be consistent within specific contexts and environments such as schools [29] and thus their investigation is warranted.

Schools are identified as important settings for health promotion through PA. In the UK, the Government's plan for action to reduce childhood obesity has reinforced the importance of school recommending that children should accumulate at least 30 min of MVPA within school every day [30]. For schools to be active environments and for successful interventions to be implemented, it is important to understand what influences PA-related behaviour during school hours. The aim of this study therefore, was to investigate the child and school-level influences on children's PA levels and ST during school hours in a sample of English children from a low-income community.

2. Materials and Methods

2.1 Participants

Seven primary schools participated in the baseline phase of the cross-sectional Active Schools: Skelmersdale (AS:Sk) study. The schools were located in Skelmersdale which is situated within the

West Lancashire borough of North-West England. The percentage of children living in income-deprived households within this area (34.6%) is above the national average for England (21.8%) and average overweight and obesity prevalence in 10–11 year olds exceeds 33% [31]. All 15 schools in the town were invited to participate in the project. Twelve schools initially expressed interest and were provided with more details, which resulted in seven schools consenting to take part. Reasons given by schools that declined to participate included lack of time to commit to the three phases of the project, and uncertainty as to whether they would be able to get parental consent for a sufficient number of children. Once ethical approval from the Faculty of Arts and Sciences Research Ethics Committee at Edge Hill University was granted (SPA-REC-2015-183), the schools received the relevant paperwork to invite all Year 5 children (ages 9–10 years; $n = 243$) to participate in the study. Returned signed parent/carer consent and child assent forms were received from a sample of 215 children aged 9–10 years (88% participation rate).

2.2 Child-Level Measures

Anthropometry. Stature was assessed to the nearest 0.1 cm using a portable stadiometer (Leicester Height Measure, Seca, Birmingham, UK). Body mass was assessed to the nearest 0.1 kg (761 scales, Seca). Body mass index (BMI) was calculated as body weight in kilograms divided by height in meters squared for each participant. BMI z-scores were assigned [32] and age and sex specific BMI cut points established children as normal weight or overweight/obese (those who were underweight were grouped into the normal weight category) [33]. Gender-specific equations were used to predict children's age from peak height velocity (APHV), as a proxy measure of biological maturation [34]. Waist circumference was measured to the nearest 0.1 cm using an anthropometric tape measure, and the percentage of waist circumference-to-height ratio (%WHtR) was calculated as a measure of central adiposity [35]. All measurements were conducted on school sites by the lead author and a research assistant using standard procedures.

2.2.1 Socio-Economic Status

Neighbourhood-level SES was calculated using the 2015 Indices of Multiple Deprivation (IMD) [36]. The IMD is a UK Government produced deprivation measure for England comprising income, employment, health, education, housing, environment, and crime. IMD rank scores were generated from parent-reported home post codes using the National Statistics Postcode Directory database. IMD rank scores were matched to their corresponding IMD deciles, where decile 1 represents the most deprived 10% of areas nationally.

2.2.2 Psychological Outcomes

Children's perceptions of PA self-efficacy and enjoyment were assessed through a paper questionnaire pack. Questions were completed by children in class time under the guidance of a class teacher, teaching assistant and at least two research assistants. Teachers were asked to indicate any children with reading or comprehension issues who were then provided with one-to-one support. Included was eight items measuring self-efficacy [37] and 16 items measuring enjoyment [38], which were measured on a 5-point scale ranging from 1 ("Strongly disagree") to 5 ("Strongly agree"). These questionnaires have previously demonstrated strong factorial validity [37,38].

2.2.3 Cardiorespiratory Fitness

The 20 m shuttle run test was conducted to provide an estimate of cardiorespiratory fitness (CRF) [39]. This well-established test has been previously used with children of a similar age to those in the current study [40,41]. The total number of shuttles completed by each participant was recorded as a proxy measure of CRF.

2.2.4 Physical Activity

Children wore an ActiGraph GT9X triaxial accelerometer (ActiGraph, Pensacola, FL, USA) on their non-dominant wrist for seven consecutive days. Children were instructed to wear the accelerometer all the time ($24 \text{ h} \cdot \text{day}^{-1}$) except when engaging in water-based activities such as bathing and swimming. The ActiGraph GT9X accelerometer uses the same validated MEMS sensor as the ActiGraph GT3X+ model [42] which has been used extensively in child PA research [43]. Log sheets were provided for children to record times when the accelerometer was removed and replaced. Data collection took place during the regular school term from May to July 2016 therefore data were representative of usual spring/summer free-living activities. Accelerometers were initialised to record raw accelerations at a frequency of 30 Hz. After 7 days of wear, accelerometer data were downloaded using ActiLife version 6.11.8 (ActiGraph) and saved in raw format as GT3X files. These were subsequently converted to CSV format to facilitate raw data processing. Files were processed in R (<http://cran.r-project.org>) using the package GGIR (version 1.1–4). GGIR converted the raw triaxial accelerometer signals into one omnidirectional measure of acceleration termed the Euclidean norm minus one (ENMO; vector magnitude taken from the three axes minus the value of gravity with negative values rounded up to zero) [44,45]. ENMO values were averaged per 1 s epoch over each of the seven monitored days [46]. Accelerometer non-wear was determined using the method of van Hees et al. [44], which has been applied previously in ActiGraph studies involving children [46–48]. Briefly, non-wear time was estimated from the standard deviation and value range of each accelerometer axis, calculated for moving windows of 60-min with 15-min increments [44]. Accelerometer wear time inclusion criteria were at least $16 \text{ h} \cdot \text{day}^{-1}$ for a minimum of three weekdays [49]. This minimum wear time criteria is sufficient to produce reliable estimates of PA [50]. After children without sufficient wear time were excluded from the data set, there was an analytical sample of 169 children, whose descriptive characteristics did not differ from those of the excluded children. Published ENMO prediction equations were used to identify cut-points for classifying activity into ST, LPA, and MVPA [51]. Previously, children's ST has commonly been defined as being equivalent to 1.5 METs based on standard MET-based definitions in adults [52]. Better classification accuracy for differentiating ST (from LPA) has though been reported using 2 METs which accounts for the higher energy expenditure of children relative to adults [52]. Therefore, the Hildebrand equations were solved for 2 METs (ST/LPA) and 4 METs (MVPA) resulting in ENMO cut-points of 33 mg for LPA, and 370 mg for moderate PA (MPA), respectively. Sleep was estimated within the GGIR R package (version 1.2–11; <http://cran.r-project.org>). Briefly, nocturnal periods of time where there was no change in arm angle greater than 5 degrees over at least 5 min, were classified as sleep periods [53].

2.3. School-Level Measures

2.3.1. School PA Provision Survey

Head teachers or the most appropriate alternate member of staff from each school completed a 20-item survey to indicate school PA environment, practices, and provision. The survey was available to complete online or in paper format. Three existing U.S.-based PA audit tools were used and adapted to create UK-culturally appropriate questions (i.e., School Physical Activity Policy Assessment; School Health Index) [54,55]. Questions covered various parts of the school day relating to PA, including the amount of provision before and after school as well as aspects relating to recess and PE lessons. A 4-point scale was used to answer questions (0–3), with a score of 3 representing optimal PA environment/practice/provision and 0 representing poor or non-existent PA environment/practice/provision. The item scores were summed, divided by 60, and converted to percentage scores.

2.3.2. Playground Space

Aerial views of the schools^t playground areas were located using the GoogleTM Earth Pro application (version 7.1). Playground areas were calculated using the polygon tool and summed for each school to provide an estimate of playground spatial area [56,57]. The number of enrolled children in each school (number on roll) was obtained from school records.

2.4. Data Analysis

Individual and school level descriptive statistics (mean \pm SD) were calculated for all measured variables. Independent t-tests assessed sex differences in the main outcomes of ST, LPA, and MVPA. To account for the clustering of children within the seven schools, multilevel modelling was performed for the main analysis using MLwiN Version 2.02 [58]. A 2-level data structure defining children as the first level unit of analysis and schools as the second level unit was used [59]. Separate multilevel prediction models with random intercepts were constructed to identify significant predictors of ST, LPA, and MVPA during the school day (range 8.45 am–3.15 pm), morning break (mean 15.7 min), lunch break (time on the playground only, mean 37.9 min) and total PE time (mean 90.7 min; 12 models in total). Morning break and lunch break periods were daily occurrences for all participating schools, PE frequency differed between schools and was either once or twice per school week. School- and child-level predictors were entered into the models and were retained when they were significantly associated with the outcomes and remained significant when subsequent predictors were added to the models. Therefore, non-significant predictors which were not in the final models were not presented in the results. Regression coefficients in the models were assessed for significance using the Wald statistic and the alpha level was set at $p < 0.05$ [59].

3. Results

3.1 Exploratory Analyses

The descriptive characteristics of the 215 children are displayed in Table 1. Around one-quarter of the children were classified as overweight or obese. The deprivation deciles of home postcodes ranged from 1 to 9, with 85% of children living within deciles 1–3. One hundred and eighty-six children met the wear time inclusion criteria (87% compliance) and were subsequently included in the main analyses. Table 2 presents the mean number of minutes spent in different PA intensities during weekdays, indicating that boys and girls did not achieve the recommended 60 min of MVPA on average. The mean number of minutes spent in the different PA intensities across the studied segments (school day/morning break/lunch break/PE) are also presented in Table 2.

Table 1. Descriptive characteristics of participating children (Mean (SD) unless stated).

Characteristics	Boys (<i>n</i> = 110)	Girls (<i>n</i> = 105)
Age (year)	10.2 (0.3)	10.2 (0.3)
Stature (cm)	140.4 (5.9)	141.3 (6.8)
Body Mass (kg)	36.4 (8.4)	38.3 (10.6)
BMI (kg·m ²)	18.9 (4.0)	18.3 (3.2)
BMI z-score	0.5 (1.3)	0.5 (1.3)
Weight Status		
Normal Weight (%)	76.2	72.5
Overweight/Obese (%)	23.8	27.5
Waist Circumference (cm)	64.3 (10.0)	64.9 (10.3)
Maturity Offset (y) IMD	−2.8 (0.3)	−1.6 (0.4)
Rank	5746.5 (5831.6)	6077.6 (6922.1)
IMD Decile	2.3 (1.7)	2.4 (2.1)
CRF (Number of shuttles)	30.4 (16.5)	25.4 (11.7)

CRF, cardiorespiratory fitness.

Table 2. Boys and girls sedentary time and physical activity (Mean and SD).

Boys (<i>n</i> = 92) Time Segments	Girls (<i>n</i> = 94)					
	ST	LPA	MVPA	ST	LPA	MVPA
Weekday	546.7 (115.6)	357.5 (62.8)	42.0 (17.6) ‡	553.4 (108.8)	370.6 (55.6)	30.2 (13.4) ‡
School day	198.4 (31.3) †	157.5 (27.4)	20.9 (8.7) ‡	210.4 (32.6) †	151.9 (27.9)	14.3 (7.2) ‡
Morning break	6.4 (3.0)	7.2 (2.0)	1.5 (1.1) ‡	6.5 (3.1)	7.0 (2.0)	0.8 (0.06) ‡
Lunch break	17.0 (6.2) †	7.0 (2.2) †	6.0 (4.4) ‡	19.8 (8.0) †	6.0 (2.0) †	3.1 (2.2) ‡
PE	17.1 (8.1)	34.0 (5.7)	7.3 (4.1) †	18.6 (8.5)	33.5 (6.6)	5.9 (3.6) †

ST, sedentary time; LPA, light physical activity; MVPA, moderate to vigorous physical activity. † Significant difference between sexes, $p < 0.05$. ‡ Significant difference between sexes, $p < 0.001$.

3.2 Main Analyses

School-level predictors entered into the multilevel models were number of enrolled students, playground area, and PA provision score (Table 3). Only six out of seven schools were included for the PA provision scores due to non-completion of the survey by one school. The multilevel analyses are reported in Tables 4–7.

Table 3. Descriptive school level predictors.

Variable	Mean (SD)	Range
No. enrolled students	277.6 (150.5)	102–579
Playground area (m ²)	2071.6 (815.5)	904–3121
PA provision score (%)	62.3 (9.5)	52–75

3.3 School Day Predictors

The only correlate to significantly predict school day ST was school day MVPA levels ($p < 0.001$), whereby one minute of MVPA during the school day predicted 1.9 min less ST during the same period ($p < 0.001$). Participation in school day ST predicted less participation in LPA (0.9 min, $p < 0.001$) and MVPA (0.1 min, $p < 0.001$) during the school day. CRF ($p < 0.001$) and number on roll ($p = 0.01$) were also inverse predictors of school day LPA. Conversely, CRF was a positive predictor of school day MVPA ($p < 0.001$), while maturity offset was an inverse predictor of school day MVPA ($p < 0.001$). Out of school MVPA was a significant inverse predictor of LPA in the school day ($p < 0.001$) and a significant positive predictor of MVPA in the school day ($p < 0.001$).

3.4 Morning Break Predictors

MVPA during the school day predicted less ST participation during morning break ($p < 0.001$). ST during the school day also predicted less morning break LPA ($p < 0.001$) and MVPA ($p < 0.001$) but by only 0.1 min. Out of school MVPA predicted less participation in LPA during morning break ($p = 0.02$). Number on roll positively predicted ST ($p = 0.01$) and LPA ($p < 0.001$) at morning break. Those who were overweight or obese participated in significantly less MVPA during morning break ($p = 0.01$), and maturity offset was also an inverse predictor of MVPA ($p < 0.001$).

3.5 Lunch Break Predictors

MVPA during the school day predicted less ST participation during lunch break ($p < 0.001$). ST during the school day also predicted less lunch break LPA ($p < 0.001$) and MVPA ($p < 0.001$). Out of school MVPA predicted more MVPA participation during lunch break ($p = 0.002$). Number on roll was a positive predictor of both ST ($p = 0.045$) and MVPA ($p < 0.001$) during lunch break. WtHR predicted less MVPA during lunch break by 9 min ($p < 0.001$).

Table 4. Multilevel associations between child and school level predictors and school day sedentary time and physical activity.

Correlate	School Day ST		School Day LPA		School Day MVPA	
	β (SE) ¹	95% CI	β (SE)	95% CI	β (SE)	95% CI
Constant	235.65 (5.92) ‡	224.05 to 247.25	354.0 (7.12) ‡	340.04 to 368.0	24.01 (5.0) ‡	14.21 to 33.81
Child level variables						
Maturity Offset (y)	NE ²		NE		−3.26 (0.60) ‡	−4.44 to −2.08
CRF (total shuttles)	NE		−0.07 (0.03) †	−0.13 to −0.01	0.06 (0.03) ‡	0.00 to 0.12
School day ST	NE		−0.87 (0.02) ‡	−0.91 to −0.83	−0.11 (0.02) ‡	−0.15 to −0.07
School day MVPA	−1.92 (0.21) ‡	−2.33 to −1.51	NE		NE	
Out of school MVPA	NE		−0.32 (0.07) ‡	−0.46 to −0.18	0.25 (0.06) ‡	0.13 to 0.37
School level variables						
No. on roll	NE		−0.04 (0.02) †	−0.08 to −0.00	NE	
Playground area (m ²)	NE		NE		0.002 (0.00) †	0.00 to 0.00
School level variance	138.12 (84.44)		47.34 (26.22)		6.12 (3.91)	
Child level variance	419.16 (44.31)		30.60 (3.26)		25.29 (2.73)	
ICC	0.25		0.61		0.19	

¹ Beta values reflect differences in minutes of ST/LPA/MVPA for every 1 measured unit of each predictor variable. ² NE = not entered in final model. ST, sedentary time; LPA, light physical activity; MVPA, moderate to vigorous physical activity; CRF, cardiorespiratory fitness; ICC, intraclass correlation coefficient. † $p < 0.05$, ‡ $p < 0.001$.

Table 5. Multilevel associations between child and school level predictors and morning break sedentary time and physical activity.

Correlate	Morning Break ST		Morning Break LPA		Morning Break MVPA	
	β (SE) ¹	95% CI	β (SE)	95% CI	β (SE)	95% CI
Constant	3.83 (1.13) ‡	1.62 to 6.04	12.52 (1.07) ‡	10.42 to 14.62	2.33 (0.49) ‡	1.37 to 3.29
Child level variables						
Maturity Offset (y)	NE ²		NE		−0.36 (0.11) ‡	−0.58 to −0.14
Weight Status ³	NE		NE		−0.28 (0.12) ‡	−0.52 to −0.05
School day ST	NE		−0.04 (0.00) ‡	−0.04 to −0.03	−0.01 (0.00) ‡	−0.01 to −0.00
School day MVPA	−0.07 (0.01) ‡	−0.09 to −0.05	NE		NE	
Out of school MVPA	NE		−0.03 (0.01) ‡	−0.05 to −0.01		
School level variables						
No. on roll	0.01 (0.00) ††	0.00 to 0.02	0.007 (0.00) ‡	0.00 to 0.01	NE	
School level variance	1.77 (0.98)		0.65 (0.39)		0.0 (0.04)	
Child level variance	1.52 (0.16)		1.42 (0.15)		0.43 (0.05)	
ICC	0.54		0.31		0.00	

¹ Beta values reflect differences in minutes of ST/LPA/MVPA for every 1 measured unit of each predictor variable. ² NE = not entered in final model. ³ Reference group for weight status was normal weight. ST, sedentary time; LPA, light physical activity; MVPA, moderate to vigorous physical activity; ICC, intraclass correlation coefficient. † $p < 0.05$, †† $p < 0.01$, ‡ $p < 0.001$.

Table 6. Multilevel associations between child and school level predictors and lunch break sedentary time and physical activity.

Correlate	Lunch Break ST		Lunch Break LPA		Lunch Break MVPA	
	β (SE) ¹	95% CI	β (SE)	95% CI	β (SE)	95% CI
Constant	10.70 (4.95) ††	1.0 to 20.4	17.77 (1.12) ‡	15.57 to 19.97	8.98 (2.43) ‡	4.13 to 13.74
Child level variables						
WtHR	NE ²		NE		−9.28 (2.96) ‡	−15.08 to −3.48
School day ST	NE		−0.06 (0.01) ‡	−0.08 to −0.04	−0.03 (0.00) ‡	−0.05 to −0.02
School day MVPA	−0.33 (0.04) ‡	−0.09 to −0.05	NE		NE	
Out of school MVPA	NE		NE		0.09 (0.03) ††	0.03 to 0.15
School level variables						
No. on roll	0.04 (0.02) ‡	0.00 to 0.02	NE		0.02 (0.00) ‡	0.001 to 0.03
School level variance	33.45 (18.16)		2.72 (1.52)		1.50 (0.96)	
Child level variance	11.4 (1.2)		2.25 (0.24)		6.24 (0.66)	
ICC	0.75		0.55		0.19	

¹ Beta values reflect differences in minutes of ST/LPA/MVPA for every 1 measured unit of each predictor variable. ² NE = not entered in final model. ST, sedentary time; LPA, light physical activity; MVPA, moderate to vigorous physical activity; WtHR waist to height ratio; ICC, intraclass correlation coefficient. † $p < 0.05$, †† $p < 0.01$, ‡ $p < 0.001$.

Table 7. Multilevel associations between child and school level predictors and PE sedentary time and physical activity.

Correlate	PE ST		PE LPA		PE MVPA	
	β (SE) ¹	95% CI	β (SE)	95% CI	β (SE)	95% CI
Constant	21.58 (2.48) ‡	16.72 to 26.44	54.84 (3.74) ‡	47.51 to 62.17	2.80 (2.63)	−2.35 to 7.95
Child level variables						
Maturity Offset (y)	NE ²		NE		−0.99 (0.29) ‡	−1.56 to −0.42
Weight Status ³	NE		2.15 (0.83) ††	0.52 to 3.78	NE	
PA Enjoyment	NE		NE		1.22 (0.34) ‡	0.55 to 1.89
School day ST	NE		−0.10 (0.01) ‡	−0.12 to −0.08	−0.02 (0.00) ††	−0.04 to −0.01
School day MVPA	−0.29 (0.06) ‡	−0.41 to −0.17	NE		NE	
Out of school MVPA	NE		−0.12 (0.05) †	−0.22 to −0.02	0.13 (0.03) ‡	0.07 to 0.19
School level variables						
School level variance	33.55 (18.90)		26.91 (14.87)		6.55 (3.66)	
Child level variance	35.67 (3.78)		20.31 (2.15)		5.86 (0.63)	
ICC	0.48		0.57		0.53	

¹ Beta values reflect differences in minutes of ST/LPA/MVPA for every 1 measured unit of each predictor variable. ² NE = not entered in final model. ³ Reference group for weight status was normal weight. ST, sedentary time; LPA, light physical activity; MVPA, moderate to vigorous physical activity; ICC, intraclass correlation coefficient. † $p < 0.05$, †† $p < 0.01$, ‡ $p < 0.001$.

3.6 PE Lesson Predictors

Inverse relationships were evident between school day MVPA and ST during PE ($p < 0.001$), as well as school day ST and LPA ($p < 0.001$) and MVPA ($p < 0.001$) during PE. Overweight or obese children engaged in significantly more LPA during PE than normal weight children (2.6 min, $p = 0.001$). Further positive predictors of PE MVPA were PA enjoyment ($p < 0.001$) and out of school MVPA ($p < 0.001$), while maturity offset was an inverse predictor of MVPA during PE lessons ($p < 0.001$).

4. Discussion

This study investigated predictors of low-income children's school environment PA levels and ST. Significant child-level predictors were maturity offset, CRF, weight status, WtHR, ST, and MVPA, while the significant school-level predictors were number of children on roll and playground area. Previous research has reported variables such as sex, SES, and self-efficacy to be predictors of children's habitual PA [28]. However, these predictors were not associated with PA or ST during the whole school day or specific segments of the school day in this study. The fact that SES was not a significant predictor was likely due to the homogeneity in the children's IMD scores. The exploration of children's time-specific PA has identified age and gender to be consistently associated with school morning break PA [29]. Significant differences were observed between boys and girls for school day ST and MVPA, for MVPA during morning break and PE, and for lunch break ST, LPA, and MVPA in the current study, but sex was not significantly related to ST or PA in the multilevel analyses. Previous research has shown the effect of sex on PA to reduce or even disappear when maturity status is controlled for [60,61]. This research may explain why sex did not predict ST and PA, but maturity offset significantly predicted MVPA during the school day, morning break, and PE. Disengagement from PA aligning with maturation is associated with a variety of behavioural, social and biological factors [62]. Furthermore, the contribution of biological maturity to variation in PA should consider factors such as activity context [62]. Our results indicate that children's maturity status influences MVPA in the school environment, thus it is important to understand how school PA practices and policies recognise this influence to enable all children to engage in MVPA during school hours regardless of their maturity status. Furthermore, the children in this study were largely pre- and early-pubescent. The influence of maturation may be exacerbated in high school environments as PA is known to gradually decline as adolescents progress toward the mature state, i.e., adulthood [63].

Sedentary time and MVPA were the most consistent predictors across the different periods, with MVPA significantly predicting less ST, and ST levels significantly predicting less MVPA. This is consistent with previous research studying break time periods of the school day, in which an inverse association was reported between sedentary activities and percentage of time engaged in MVPA [64]. Whilst our analysis found that one behaviour predicted less of another, this does not imply that ST displaces PA and vice versa. Marshall and colleagues [65] found correlations between sedentary behaviours and PA to be small and positive, suggesting ST does compete with and coexist with PA. However, small increases in MVPA levels within the school environment which help to reduce ST should be advocated due to the known health and development benefits of MVPA and negative health implications of excessive ST in children [13]. The replacement of sedentary behaviour with PA is also of particular importance for children who are overweight or obese. Weight status was a significant predictor in the current study, with those who were overweight or obese participating in less MVPA during morning break for example. Results from intervention studies suggest that preventing excessive sedentary behaviour may be an effective approach in improving healthy weight among children [66]. As overweight/obese children have a higher chance of becoming overweight or obese as adults and subsequently being at risk for chronic diseases [67], advocating reduced ST and increased MVPA in the school setting among this group is important. Additionally, out of school MVPA was a significant inverse predictor of LPA during the school day, morning break and PE, and a significant positive predictor of MVPA during the school day, lunch break and PE. Given that activity during the school day was low overall, it appears that children who accrued more MVPA out of school participated

in more during school, regardless of individual schools^t PA provision. Conversely, creating more opportunities for activity during the school day can prompt higher activity levels to be sustained out of school, which lends further support for promoting MVPA participation in the school setting [68]. A significant predictor of MVPA during PE lessons was PA enjoyment. This reinforces the need for children^ts PA experiences to be fun and enjoyable as PA enjoyment is a recognised mediator of behavioural change in PA interventions [69]. This finding aligns with theories of motivation, in that the participation in activities for joy or pleasure results in a greater adherence due to participants being intrinsically motivated to engage [70]. Enjoyment is a key principle of the recently proposed “SAAFE” framework for the design and delivery of organised PA sessions for children and adolescents [70]. Our findings support this principle in relation to MVPA participation during PE lessons. This is of significance due to the importance of PE within the school environment; research has shown that PE plays a considerable role in providing PA for children with increased activity levels on days in which PE is provided [18]. Furthermore, PE can develop fitness, gross motor skills and overall health [16]. PA provision scores obtained by schools also significantly predicted PE MVPA levels. In the context of UK schools there is a need for an objective measure, which captures how schools operate in relation to PA provision, as opposed to the US based tools previously published [54,55]. Within UK schools government funding is provided to improve the quality and breadth of PE and sports provision in primary schools worth £150 million per year [71]. Whilst not exclusively for PE delivery, UK schools have the freedom to determine how best to use this funding to improve curricular and non-curricular PA provision, but are expected to be accountable for measuring the impact of their spending [71]. Elsewhere, such as in the U.S., school based PA opportunities differ from state to state, district to district and from school to school based on decisions made by state policy makers [72]. Local policies and the degree to which they are adhered to or enforced there, impacts children’s PA accrual in schools [54]. Given the differences between school operations in these examples of the UK and U.S., objective tools to measure school based PA provision which are country-specific would be useful to help schools decide on how to use funding or to help policy makers understand what is being done at the level of individual schools. Furthermore, the use of an objective tool would be useful for researchers who wish to implement school-based interventions targeting areas of the school day most in need of intervention. In our analyses, school-level variables had limited associations with ST, LPA, or MVPA. Furthermore, PA provision scores from the audit tool did not explain or capture the differences between schools. Variance of activity levels explained by differences between schools were substantial, suggesting behaviours during periods of the school day varied between the participating schools. For example 54% of morning break and 75% of lunch break ST variance was explained by differences between schools. In comparison, a study examining children’s ST and MVPA during recess found total variance explained by differences between schools to be 12% for ST [73]. It is unclear why the between-school variance is higher than was reported by Ridgers et al. (2010) [73], particularly for ST. There are however a range of different factors related to school break times which can vary between individual schools. The current analyses included PA provision, playground space, and number of children, while other studies have shown provision of equipment, climate, and number of permanent play facilities to be associated with PA behaviour [73,74]. Thus, differences such as these which are particular to individual schools impact children’s ST and PA, and serve to highlight the need for analyses to account for the contribution of schools to PA outcome variance.

Number of children on roll inconsistently predicted ST and PA, depending on the period. For example, at morning break number on roll predicted more ST and LPA, whilst at lunch break it was associated with more ST and MVPA. A review of the overall PA behaviour of 10–18 year olds found the presence of peers and friends to be associated with PA [75]. This is to be expected in contexts such as morning break and lunch break, particularly in younger age groups, as peers will always be present. A systematic review of PA during school recess found 48 studies that reported a negative association between number on roll and PA and 38 studies reporting no association [76]. Given the inconsistencies of the current study and that of previous research, methodologies such as context-specific systematic

observations and tools (e.g., SOCARP) [77] would help to further our understanding of children's PA-related social dynamics and behaviours.

The subjective nature of the audit tool used and its completion by school staff is a limitation of the current study. A further limitation was the use of timetabled school times to define the segments of break and lunch times and PE. Actual recording of specific school period times during monitor wear by teachers would allow greater certainty that the activity recorded took place in the period of interest. This though would place additional burden on class teachers to record these times on multiple occasions each day. A greater range of school-level predictors may have better explained differences between schools, for example the presence of equipment during break and lunch breaks, fixed equipment and playground markings. The most important limitation is the cross-sectional nature of the research design which prevents conclusions to be made regarding causality. A strength of this study was the use of objectively assessed PA. Furthermore, the use of raw accelerations avoids the uncertainty of pre-processed data such as counts and the possibility that signal filtering methods alter study results [78,79]. The use of raw data also gives an increased control over data processing as well as the opportunity to improve comparability and consistency between studies which use different monitors for example [51]. In addition, the multilevel analyses allowed for the nested nature of children within schools and also school level correlates to be studied.

5. Conclusions

The most consistent child-level predictors of behaviour were levels of MVPA and ST, and maturity offset. School-level predictors were more inconsistent but included of children on roll and playground area. Understanding school-level variables which influence PA would be useful for both schools and researchers who wish to increase school based PA. The school environment is of great importance for PA promotion in children, which is exemplified by the UK government's aim for children to accrue 30 min of MVPA during the school day [30]. Future research should consider setting-specific PA and its correlates/predictors within specific school days contexts.

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References

1. Janssen, I.; Leblanc, A.G. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *Int. J. Behav. Nutr. Phys. Act.* **2010**. [CrossRef] [PubMed]
2. Andersen, L.B.; Riddoch, C.; Kriemler, S.; Hills, A. Physical activity and cardiovascular risk factors in children. *Br. J. Sports Med.* **2011**, *45*, 871–876. [CrossRef] [PubMed]
3. Boddy, L.M.; Murphy, M.H.; Cunningham, C.; Breslin, G.; Foweather, L.; Gobbi, R.; Graves, L.E.F.; Hopkins, N.D.; Auth, M.K.H.; Stratton, G. Physical activity, cardiorespiratory fitness, and clustered cardiometabolic risk in 10- to 12-year-old school children: The REACH Y6 study. *Am. J. Hum. Biol.* **2014**, *26*, 446–451. [CrossRef] [PubMed]
4. Lubans, D.; Richards, J.; Hillman, C.; Faulkner, G.; Beauchamp, M.; Nilsson, M.; Kelly, P.; Smith, J.; Raine, L.; Biddle, S. Physical Activity for Cognitive and Mental Health in Youth: A Systematic Review of Mechanisms. *Pediatrics* **2016**. [CrossRef] [PubMed]
5. Department of Health, Physical Activity, Health Improvement and Protection. Start Active, Stay Active: A Report on Physical Activity from the Four Home Countries' Chief Medical Officers. Available online: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/216370/dh_128210.pdf (accessed on 29 March 2017).

6. 2008 Physical Activity Guidelines for Americans Services. Available online: <https://health.gov/paguidelines/guidelines/summary.aspx> (accessed on 29 March 2017).
7. Make Your Move—Sit Less—Be Active for Life! Australia's Physical Activity and Sedentary Behaviour Guidelines for Children (5–12 Years). Available online: http://www.health.gov.au/internet/main/publishing.nsf/content/F01F92328EDADA5BCA257BF0001E720D/\protect\T1\textdollarFile/brochure%20PA%20Guidelines_A5_5-12yrs.PDF (accessed on 29 March 2017).
8. Tremblay, M.S.; Barnes, J.D.; Gonzalez, S.A.; Katzmarzyk, P.T.; Onywera, V.O.; Reilly, J.J.; Tomkinson, G.R. Global Matrix 2.0: Report Card Grades on the Physical Activity of Children and Youth Comparing 38 Countries. *J. Phys. Act. Health* **2016**, *13*, S343–S366. [[CrossRef](#)] [[PubMed](#)]
9. Cooper, A.R.; Goodman, A.; Page, A.S.; Sherar, L.B.; Esliger, D.W.; van Sluijs, E.M.F.; Andersen, L.B.; Anderssen, S.; Cardon, G.; Davey, R.; et al. Objectively measured physical activity and sedentary time in youth: The International children's accelerometry database (ICAD). *Int. J. Behav. Nutr. Phys. Act.* **2015**. [[CrossRef](#)] [[PubMed](#)]
10. Ekelund, U.; Tomkinson, G.; Armstrong, N. What proportion of youth are physically active? Measurement issues, levels and recent time trends. *Br. J. Sports Med.* **2011**, *45*, 859–865. [[CrossRef](#)] [[PubMed](#)]
11. Saunders, T.J.; Chaput, J.-P.; Tremblay, M.S. Sedentary Behaviour as an Emerging Risk Factor for Cardiometabolic Diseases in Children and Youth. *Can. J. Diabetes* **2014**, *38*, 53–61. [[CrossRef](#)] [[PubMed](#)]
12. Tremblay, M.S.; Carson, V.; Chaput, J.P.; Connor Gorber, S.; Dinh, T.; Duggan, M.; Faulkner, G.; Gray, C.E.; Gruber, R.; Janson, K.; et al. Canadian 24-Hour Movement Guidelines for Children and Youth: An Integration of Physical Activity, Sedentary Behaviour, and Sleep. *Appl. Physiol. Nutr. Metab.* **2016**, *41*, S311–S327. [[CrossRef](#)] [[PubMed](#)]
13. Carson, V.; Hunter, S.; Kuzik, N.; Gray, C.E.; Poitras, V.J.; Chaput, J.P.; Saunders, T.J.; Katzmarzyk, P.T.; Okely, A.D.; Connor Gorber, S.; et al. Systematic review of sedentary behaviour and health indicators in school-aged children and youth: An update. *Appl. Physiol. Nutr. Metab.* **2016**, *41*, S240–S265. [[CrossRef](#)] [[PubMed](#)]
14. Ekris, E.; Altenburg, T.M.; Singh, A.S.; Proper, K.I.; Heymans, M.W.; Chinapaw, M.J.M. An evidence-update on the prospective relationship between childhood sedentary behaviour and biomedical health indicators: A systematic review and meta-analysis. *Obes. Rev.* **2016**, *17*, 833–849. [[CrossRef](#)] [[PubMed](#)]
15. Suchert, V.; Hanewinkel, R.; Isensee, B. Sedentary behavior and indicators of mental health in school-aged children and adolescents: A systematic review. *Prev. Med.* **2015**, *76*, 48–57. [[CrossRef](#)] [[PubMed](#)]
16. The National Academies Press. *Educating the Student Body: Taking Physical Activity and Physical Education to School*; The National Academies Press: Washington, DC, USA, 2013.
17. Ridgers, N.D.; Stratton, G.; Fairclough, S.J. Physical activity levels of children during school playtime. *Sports Med.* **2006**, *36*, 359–371. [[CrossRef](#)] [[PubMed](#)]
18. Meyer, U.; Roth, R.; Zahner, L.; Gerber, M.; Puder, J.J.; Hebestreit, H.; Kriemler, S. Contribution of physical education to overall physical activity. *Scand. J. Med. Sci. Sports* **2013**, *23*, 600–606. [[CrossRef](#)] [[PubMed](#)]
19. Fox, K.R.; Cooper, A.; McKenna, J. The School and Promotion of Children's Health-Enhancing Physical Activity: Perspectives from the United Kingdom. *J. Teach. Phys. Educ.* **2004**, *23*, 338–358. [[CrossRef](#)]
20. Naylor, P.J.; McKay, H.A. Prevention in the first place: Schools a setting for action on physical inactivity. *Br. J. Sports Med.* **2009**, *43*, 10–13. [[CrossRef](#)] [[PubMed](#)]
21. Center for Chronic Disease Prevention and Health Promotion. *Comprehensive School Physical Activity Programs: A Guide for Schools*; Center for Chronic Disease Prevention and Health Promotion: Atlanta, GA, USA, 2013.
22. Tandon, P.S.; Zhou, C.; Sallis, J.F.; Cain, K.L.; Frank, L.D.; Saelens, B.E. Home environment relationships with children's physical activity, sedentary time, and screen time by socioeconomic status. *Int. J. Behav. Nutr. Phys. Act.* **2012**. [[CrossRef](#)] [[PubMed](#)]
23. Seabra, A.; Mendonca, D.; Maia, J.; Welk, G.; Brustad, R.; Fonseca, A.M.; Seabra, A.F. Gender, weight status and socioeconomic differences in psychosocial correlates of physical activity in schoolchildren. *J. Sci. Med. Sport* **2013**, *16*, 320–326. [[CrossRef](#)] [[PubMed](#)]
24. Drenowatz, C.; Eisenmann, J.C.; Pfeiffer, K.A.; Welk, G.; Heelan, K.; Gentile, D.; Walsh, D. Influence of socio-economic status on habitual physical activity and sedentary behavior in 8- to 11-year old children. *BMC Public Health* **2010**. [[CrossRef](#)] [[PubMed](#)]
25. Stalsberg, R.; Pedersen, A.V. Effects of socioeconomic status on the physical activity in adolescents: A systematic review of the evidence. *Scand. J. Med. Sci. Sports* **2010**. [[CrossRef](#)] [[PubMed](#)]

26. Sallis, J.F.; Prochaska, J.J.; Taylor, W.C. A review of correlates of physical activity of children and adolescents. *Med. Sci. Sports Exerc.* **2000**, *32*, 963–975. [[CrossRef](#)] [[PubMed](#)]
27. Bauman, A.E.; Reis, R.S.; Sallis, J.F.; Wells, J.C.; Loos, R.J.F.; Martin, B.W. Correlates of physical activity: Why are some people physically active and others not? *Lancet* **2012**. [[CrossRef](#)]
28. Sterdt, E.; Liersch, S.; Walter, U. Correlates of physical activity of children and adolescents: A systematic review of reviews. *Health Educ. Res.* **2013**, *73*, 72–89. [[CrossRef](#)]
29. Stanley, R.M.; Ridley, K.; Dollman, J. Correlates of children's time-specific physical activity: A review of the literature. *Int. J. Behav. Nutr. Phys. Act.* **2012**. [[CrossRef](#)] [[PubMed](#)]
30. Childhood Obesity: A Plan for Action. Available online: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/546588/Childhood_obesity_2016_cc.pdf (accessed on 29 March 2017).
31. Collins, S. Seven Wards: A Focus on Skelmersdale. Available online: www.westlancashireccg.nhs.uk/wp-content/uploads/Skelmersdale.pdf (accessed on 29 March 2017).
32. Cole, T.J.; Freeman, J.; Preece, M.A. Body mass index reference curves for the UK, 1990. *Arch. Dis. Child* **1995**, *73*, 25–29. [[CrossRef](#)] [[PubMed](#)]
33. Cole, T.J.; Bellizzi, M.C.; Flegal, K.M.; Dietz, W.H. Establishing a standard definition for child overweight and obesity worldwide: international survey. *Br. Med. J.* **2000**, *320*, 1240–1243. [[CrossRef](#)]
34. Moore, S.A.; McKay, H.A.; Macdonald, H.; Nettlefold, L.; Baxter-Jones, A.D.; Cameron, N.; Brasher, P.M. Enhancing a Somatic Maturity Prediction Model. *Med. Sci. Sports Exerc.* **2015**, *47*, 1755–1764. [[CrossRef](#)] [[PubMed](#)]
35. Mehta, S.K. Waist circumference to height ratio in children and adolescents. *Clin. Pediatr.* **2015**, *54*, 652–658. [[CrossRef](#)] [[PubMed](#)]
36. The English Indices of Deprivation 2015. Available online: <https://www.gov.uk/government/statistics/english-indices-of-deprivation-2015> (accessed on 29 March 2017).
37. Motl, R.W.; Dishman, R.K.; Trost, S.G.; Saunders, R.P.; Dowda, M.; Felton, G.; Ward, D.S.; Pate, R.R. Factorial Validity and Invariance of Questionnaires Measuring Social-Cognitive Determinants of Physical Activity among Adolescent Girls. *Prev. Med.* **2000**, *31*, 584–594. [[CrossRef](#)] [[PubMed](#)]
38. Motl, R.W.; Dishman, R.K.; Saunders, R.; Dowda, M.; Felton, G.; Pate, R.R. Measuring enjoyment of physical activity in adolescent girls. *Am. J. Prev. Med.* **2001**, *21*, 110–117. [[CrossRef](#)]
39. Léger, L.A.; Mercier, D.; Gadoury, C.; Lambert, J. The multistage 20 m shuttle run test for aerobic fitness. *J. Sport Sci.* **1988**, *6*, 93–101. [[CrossRef](#)] [[PubMed](#)]
40. Fairclough, S.J.; Hackett, A.F.; Davies, I.G.; Gobbi, R.; Mackintosh, K.A.; Warburton, G.L.; Stratton, G.; van Sluijs, E.M.; Boddy, L.M. Promoting healthy weight in primary school children through physical activity and nutrition education: A pragmatic evaluation of the CHANGE! Randomised intervention study. *BMC Public Health* **2013**. [[CrossRef](#)] [[PubMed](#)]
41. Stratton, G.; Canoy, D.; Boddy, L.M.; Taylor, S.R.; Hackett, A.F.; Buchan, I.E. Cardiorespiratory fitness and body mass index of 9–11-year-old English children: A serial cross-sectional study from 1998 to 2004. *Int. J. Obes.* **2007**, *31*, 1172–1178. [[CrossRef](#)] [[PubMed](#)]
42. Hanggi, J.M.; Phillips, L.R.; Rowlands, A.V. Validation of the GT3X ActiGraph in children and comparison with the GT1M ActiGraph. *J. Sci. Med. Sport* **2013**, *16*, 40–44. [[CrossRef](#)] [[PubMed](#)]
43. Cain, K.L.; Sallis, J.F.; Conway, T.L.; Van Dyck, D.; Calhoun, L. Using accelerometers in youth physical activity studies: A review of methods. *J. Phys. Act. Health* **2013**, *10*, 437–450. [[CrossRef](#)] [[PubMed](#)]
44. Van Hees, V.T.; Gorzelniak, L.; Dean Leon, E.C.; Eder, M.; Pias, M.; Taherian, S.; Ekelund, U.; Renstrom, F.; Franks, P.W.; Horsch, A.; et al. Separating movement and gravity components in an acceleration signal and implications for the assessment of human daily physical activity. *PLoS ONE* **2013**, *8*, e61691. [[CrossRef](#)] [[PubMed](#)]
45. Van Hees, V.T.; Fang, Z.; Langford, J.; Assah, F.; Mohammad, A.; da Silva, I.C.M.; Trenell, M.I.; White, T.; Wareham, N.J.; Brage, S. Autocalibration of accelerometer data for free-living physical activity assessment using local gravity and temperature: An evaluation on four continents. *J. Appl. Physiol.* **2014**, *117*, 738–744. [[CrossRef](#)] [[PubMed](#)]
46. Fairclough, S.J.; Noonan, R.; Rowlands, A.V.; Van Hees, V.; Knowles, Z.; Boddy, L.M. Wear Compliance and Activity in Children Wearing Wrist- and Hip-Mounted Accelerometers. *Med. Sci. Sports Exerc.* **2016**, *48*, 245–253. [[CrossRef](#)] [[PubMed](#)]

47. Rowlands, A.V.; Cliff, D.P.; Fairclough, S.J.; Boddy, L.M.; Olds, T.S.; Parfitt, G.; Noonan, R.J.; Downs, S.J.; Knowles, Z.R.; Beets, M.W. Moving Forward with Backward Compatibility: Translating Wrist Accelerometer Data. *Med. Sci. Sports Exerc.* **2016**, *48*, 2142–2149. [CrossRef] [PubMed]
48. Noonan, R.J.; Boddy, L.M.; Kim, Y.; Knowles, Z.R.; Fairclough, S.J. Comparison of children's free-living physical activity derived from wrist and hip raw accelerations during the segmented week. *J. Sport Sci.* **2016**. [CrossRef] [PubMed]
49. Sabia, S.; van Hees, V.T.; Shipley, M.J.; Trenell, M.I.; Hagger-Johnson, G.; Elbaz, A.; Kivimäki, M.; Singh-Manoux, A. Association Between Questionnaire- and Accelerometer-Assessed Physical Activity: The Role of Sociodemographic Factors. *Am. J. Epidemiol.* **2014**, *179*, 781–790. [CrossRef] [PubMed]
50. Rich, C.; Geraci, M.; Griffiths, L.; Sera, F.; Dezauteux, C.; Cortina-Borja, M. Quality Control Methods in Accelerometer Data Processing: Defining Minimum Wear Time. *PLoS ONE* **2013**, *8*, e67206. [CrossRef] [PubMed]
51. Hildebrand, M.; Van Hees, V.T.; Hansen, B.H.; Ekelund, U. Age group comparability of raw accelerometer output from wrist- and hip-worn monitors. *Med. Sci. Sports Exerc.* **2014**, *46*, 1816–1824. [CrossRef] [PubMed]
52. Saint-Maurice, P.; Kim, Y.; Welk, G.; Gaesser, G. Kids are not little adults: What MET threshold captures sedentary behavior in children? *Eur. J. Appl. Physiol.* **2016**, *116*, 29–38. [CrossRef] [PubMed]
53. Van Hees, V.T.; Sabia, S.; Anderson, K.N.; Denton, S.J.; Oliver, J.; Catt, M.; Abell, J.G.; Kivimäki, M.; Trenell, M.; Singh-Manoux, A. A Novel, Open Access Method to Assess Sleep Duration Using a Wrist-Worn Accelerometer. *PLoS ONE* **2015**, *10*, e0142533. [CrossRef] [PubMed]
54. Lounsbury, M.A.F.; McKenzie, T.L.; Morrow, J.J.R.; Holt, K.A.; Budnar, R.G. School physical activity policy assessment. *J. Phys. Act. Health* **2013**, *10*, 496–503. [CrossRef] [PubMed]
55. Brener, N.D.; Pejarvara, A.; Barrios, L.C.; Crossett, L.; Lee, S.M.; McKenna, M.; Michael, S.; Wechsler, H. Applying the School Health Index to a Nationally Representative Sample of Schools. *J. Sch. Health* **2006**, *76*, 57–66. [CrossRef] [PubMed]
56. Fairclough, S.J.; Ridgers, N.D.; Welk, G. Correlates of children's moderate and vigorous physical activity during weekdays and weekends. *J. Phys. Act. Health* **2012**, *9*, 129–137. [CrossRef] [PubMed]
57. Fairclough, S.J.; Beighle, A.; Erwin, H.; Ridgers, N.D. School day segmented physical activity patterns of high and low active children. *BMC Public Health* **2012**. [CrossRef] [PubMed]
58. Rasbash, J.; Charlton, C.; Browne, W.J.; Healy, M.; Cameron, B. *MLwiN Version 2.02*; Centre for Multilevel Modelling, University of Bristol: Bristol, UK, 2005.
59. Twisk, J.W.R. *Practical Guides to Biostatistics and Epidemiology: Applied Multilevel Analysis*; Cambridge University Press: Cambridge, UK, 2006; ISBN: 978-0-52-161498-6.
60. Fairclough, S.J.; Ridgers, N.D. Relationships between maturity status, physical activity, and physical self-perceptions in primary school children. *J. Sport Sci.* **2010**, *28*, 1–9. [CrossRef] [PubMed]
61. Bacil, E.D.; Mazzardo Junior, O.; Rech, C.R.; Legnani, R.F.; de Campos, W. Physical activity and biological maturation: A systematic review. *Rev. Paul. Pediatr.* **2015**, *33*, 114–121. [CrossRef] [PubMed]
62. Sherar, L.B.; Cumming, S.P.; Eisenmann, J.C.; Baxter-Jones, A.D.G.; Malina, R.M. Adolescent biological maturity and physical activity: Biology meets behavior. *Pediatr. Exerc. Sci.* **2010**, *22*, 332–349. [CrossRef] [PubMed]
63. Cumming, S.P.; Sherar, L.B.; Esliger, D.W.; Riddoch, C.J.; Malina, R.M. Concurrent and prospective associations among biological maturation, and physical activity at 11 and 13 years of age. *Scand. J. Med. Sci. Sports* **2014**, *24*, e20–e28. [CrossRef] [PubMed]
64. Roberts, S.J.; Fairclough, S.J.; Ridgers, N.D.; Porteous, C. An observational assessment of physical activity levels and social behaviour during elementary school recess. *Health Educ. J.* **2012**, *72*, 254–262. [CrossRef]
65. Marshall, S.J.; Biddle, S.J.H.; Sallis, J.F.; McKenzie, T.L.; Conway, T.L. Clustering of Sedentary Behaviors and Physical Activity among Youth: A Cross-National Study. *Pediatr. Exerc. Sci.* **2002**, *14*, 401–417. [CrossRef]
66. Van Grieken, A.; Ezendam, N.P.; Paulis, W.D.; van der Wouden, J.C.; Raat, H. Primary prevention of overweight in children and adolescents: A meta-analysis of the effectiveness of interventions aiming to decrease sedentary behaviour. *Int. J. Behav. Nutr. Phys. Act.* **2012**. [CrossRef] [PubMed]
67. Make a Difference at Your School! Available online: <https://www.cdc.gov/healthyyouth/keystrategies/pdf/make-a-difference.pdf> (accessed on 29 March 2017).
68. Dale, D.; Corbin, C.B.; Dale, K.S. Restricting opportunities to be active during school time: Do children compensate by increasing physical activity levels after school? *Res. Q. Exerc. Sport* **2000**, *71*, 240–248. [CrossRef] [PubMed]
69. Salmon, J.; Brown, H.; Hume, C. Effects of strategies to promote children's physical activity on potential mediators. *Int. J. Obes.* **2009**, *33*, S66–S73. [CrossRef] [PubMed]
70. Lubans, D.R.; Lonsdale, C.; Cohen, K.; Eather, N.; Beauchamp, M.R.; Morgan, P.J.; Sylvester, B.D.; Smith,

- J.J. Framework for the design and delivery of organized physical activity sessions for children and adolescents: Rationale and description of the 'SAAFE' teaching principles. *Int. J. Behav. Nutr. Phys. Act.* **2017**. [CrossRef] [PubMed]
71. The PE and Sport Premium: An Investigation in Primary Schools. Available online: <https://www.gov.uk/government/publications/pe-and-sport-premium-an-investigation-in-primary-schools> (accessed on 29 March 2017).
72. Lee, S.M.; Burgeson, C.R.; Fulton, J.E.; Spain, C.G. Physical education and physical activity: Results from the School Health Policies and Programs Study 2006. *J. Sch. Health* **2007**, *77*, 435–463. [CrossRef] [PubMed]
73. Ridgers, N.D.; Fairclough, S.J.; Stratton, G. Variables associated with children's physical activity levels during recess: The A-CLASS project. *Int. J. Behav. Nutr. Phys. Act.* **2010**. [CrossRef] [PubMed]
74. Taylor, R.W.; Farmer, V.L.; Cameron, S.L.; Meredith-Jones, K.; Williams, S.M.; Mann, J.I. School playgrounds and physical activity policies as predictors of school and home time activity. *Int. J. Behav. Nutr. Phys. Act.* **2011**. [CrossRef] [PubMed]
75. Fitzgerald, A.; Fitzgerald, N.; Aherne, C. Do peers matter? A review of peer and/or friends' influence on physical activity among American adolescents. *J. Adolesc.* **2012**, *35*, 941–958. [CrossRef] [PubMed]
76. Ridgers, N.D.; Salmon, J.; Parrish, A.M.; Stanley, R.M.; Okely, A.D. Physical activity during school recess: A systematic review. *Am. J. Prev. Med.* **2012**, *43*, 320–328. [CrossRef] [PubMed]
77. Ridgers, N.D.; Stratton, G.; McKenzie, T.L. Reliability and validity of the System for Observing Children's Activity and Relationships during Play (SOCARP). *J. Phys. Act. Health* **2010**, *7*, 17–25. [CrossRef] [PubMed]
78. Freedson, P.; Bowles, H.R.; Troiano, R.; Haskell, W. Assessment of physical activity using wearable monitors: Recommendations for monitor calibration and use in the field. *Med. Sci. Sports Exerc.* **2012**, *44*, S1–S4. [CrossRef] [PubMed]
79. Peach, D.; Van Hoomissen, J.; Callender, H.L. Exploring the ActiLife® filtration algorithm: Converting raw acceleration data to counts. *Physiol. Meas.* **2014**, *35*, 2359–2367. [CrossRef] [PubMed]



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Article

Evaluation of a Pilot School-Based Physical Activity Clustered Randomised Controlled Trial – Active Schools: Skelmersdale

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Abstract: Schools are key environments in which physical activity (PA) can be promoted. Various strategies and opportunities should be used to engage children in PA within schools. The aim of this study was to evaluate the effectiveness of the multi-component Active Schools: Skelmersdale (AS:Sk) pilot intervention on children's PA and sedentary time (ST). The AS:Sk intervention was implemented for eight weeks in four schools with three control schools continuing normal practice. It consisted of eight components: active breaks, bounce at the bell, 'Born To Move' videos, Daily Mile or 100 Mile Club, playground activity challenge cards, physical education teacher training, newsletters, and activity homework. Child-level measures were collected at baseline and follow-up, including objectively measured PA. After accounting for confounding variables, the intervention had a significant effect on school day ST which was significantly less for the intervention children by 9 min per day compared to the control group. The AS:Sk pilot intervention was effective in reducing school day ST but significant changes in PA were negligible. To increase the efficacy of the current and future school-based interventions, authors should focus on implementation and process evaluations to better understand how schools are implementing intervention components.

Keywords: physical activity; intervention; schools; children; accelerometry

1. Introduction

Children and young people engage in low levels of moderate to vigorous physical activity (MVPA) [1]. Worldwide data revealed 80% of 13–15 year olds do not meet the 60 min of MVPA per day guidelines [2]. Participation in physical activity (PA) during childhood years has a favourable relationship with adiposity, cardiometabolic biomarkers such as cholesterol and blood pressure, physical fitness, and bone health [3]. Psychological outcomes such as self-worth and self-esteem are also positively affected by participation in PA [4,5]. MVPA in particular is most important for health as

relationships between health outcomes are most consistent and robust for PA of this higher intensity [3]. Moreover, in addition to low levels of activity, children's sedentary time (ST) increases during the transition from primary/middle to secondary/high school [6]. Engagement in sedentary behaviours is detrimental to many aspects of health such as body composition, cardiorespiratory fitness (CRF), metabolic syndrome, and cardiovascular disease risk factors [7].

Many barriers can prevent children and young people from engaging in regular PA [8]. As a result, it has been suggested that schools are key environments for PA promotion regardless of the individual circumstances of a child [9]. Recent government recommendations state that half (at least 30 min) of the daily recommendation for MVPA should be accrued during school hours [10,11]. Recommendations for sedentary time are less prescriptive and specific, although efforts to reduce sedentary behaviours and minimise extended periods spent sedentary across the whole day and within schools are advocated [11–14].

Within comprehensive school PA programmes (CSPAP) [15] the use of a variety of strategies and opportunities is advocated to promote PA within schools, for example during the school day, before and after school, within physical education (PE), and with involvement from staff and family/community [15]. Results from a 2015 meta-analysis indicated that as the number of CSPAP components included in an intervention increased, the effect size associated with change in daily PA also increased [16].

A comprehensive intervention perspective with a focus on multiple-level factors exemplifies a socio-ecological approach [17]. Action Schools! BC (AS! BC) is an ongoing example of an intervention underpinned by the socio-ecological model [18], and which resulted in PA increasing through activities implemented across six different school components named 'action-zones' [19]. Literature reviews have further supported this approach to intervention design, stating that interventions targeting different levels of the socioecological model and those that are multi-component in nature can have a positive impact on PA levels [20–23].

That being said, multi-component interventions are not always successful at increasing PA [24,25]. Multi-component interventions are difficult to put into practice and a lack of implementation, with schools not implementing as intended has previously been reported [24]. More recently, a more pragmatic approach to PA promotion has been proposed which includes the expansion, extension, and enhancement of PA opportunities (theory of expanded, extended, and enhanced opportunities (TEO)) [26]. The use of this approach allows researchers to target various levels within an ecological model but additionally and importantly, identify appropriate targets [26].

The Active Schools: Skelmersdale (AS:Sk) pilot multi-component clustered randomised control trial (RCT) was designed to promote PA across the school day through multiple opportunities which could be integrated into every day school life and implemented by school staff. The aim of this study was to evaluate the impact of the AS:SK intervention on children's MVPA and ST, and health indicators.

2. Materials and Methods

2.1 Participants

This study is the third phase of the AS:Sk project ([ClinicalTrials.gov](https://clinicaltrials.gov/ct2/show/study/NCT03283904) registration: NCT03283904). Seven primary schools within Skelmersdale, a low-income town, within West Lancashire, UK, participated in the project [27]. Using a sample size calculation that accounted for the pre-determined number of schools, 100 participants (50 per group) were required for a clustered RCT design with seven schools. This calculation was based on AS:Sk study 1 findings and assumed 15 participants per cluster, an intracluster correlation of 0.04, an alpha level of 0.05 and power of 90% [28,29]. Following ethical approval from the University Research Ethics Committee (ref #SPA-REC-2016-342), schools received the relevant paperwork to inform each Year 5 child ($n = 239$, age 9–10 years) about the study. Passive ("opt-out") parental consent were obtained in six of the schools, one school chose to use active parental consent, and children completed informed assent forms prior to data collection. This process resulted in 232 participating children (97% recruitment rate).

2.2 Study Design

Following the collection of baseline measurements, schools were randomly assigned to either intervention or control groups by a member of the faculty unconnected to the study. This randomisation was not blinded due to the nature of the intervention. There was a one-week gap between the allocation of groups and the beginning of the intervention period to allow for the teachers to plan and organise intervention components into their future school plans. Control schools were informed via email of their selection and agreed to continue with their usual timetabled amount of playground breaks and PE lessons without any additional time allocated for PA participation. Details of the flow of participants through the study from baseline to follow up are shown in Figure 1.

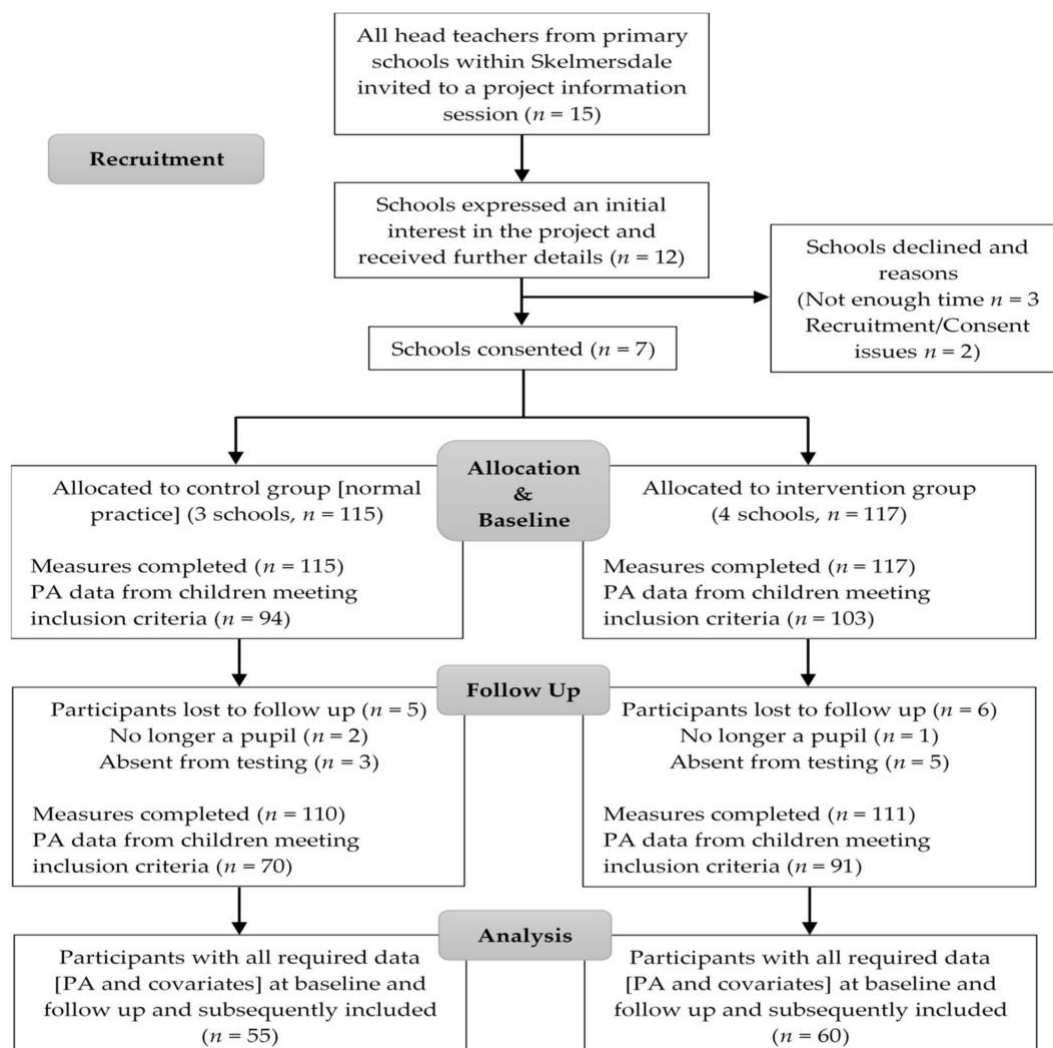


Figure 1. Flow of schools and participants through the study.

2.3 Intervention

The Consolidated Standards of Reporting Trials (CONSORT) guidelines extension for clustered RCT were followed for reporting the results of the AS:Sk intervention [30]. The intervention duration was eight weeks and it consisted of eight components. These were active breaks (ABs), bounce at the bell, 'Born To Move' (BTM) videos, Daily Mile (DM) or 100 Mile Club (MC), playground activity challenge cards, PE teacher training, newsletters, and activity homework. All intervention approaches were designed to have no financial cost to the project or schools to implement. A description of each intervention component with the recommended implementation duration and frequency per school day or week was presented to each participating class teacher who was asked to adhere to this guidance. These details are presented in Table 1. Schools were given the freedom to implement the components during the school day when it best suited their own timetable, whilst adhering to the duration and frequency guidelines. The consultation of relevant school-based intervention literature and findings from phase two of the AS:Sk project which piloted three components (ABs, BTM videos, recess intervention; unpublished data), informed selection of the current components. The components aligned with elements of the socio-ecological model [17], the youth physical activity promotion model (YPAPM) [31], and TEO [26].

Table 1. Detail of each intervention component.

Intervention Component	Content Description	Phase 2 Findings	Associated/Supportive Research	Conceptual Model/Theory	Duration	Frequency
Active Breaks	Twenty-three activity cards were created with pictures on the front demonstrating the activity and instructions on the back. All activities were designed for use within the restricted space of a classroom. Each activity card was designed to last for 30 s. (Delivery: class teacher)	Deemed feasible and acceptable. No changes needed.	Pilot primary school AB study with a similar 5-min implementation protocol [32]. ABs reported to improve PA during school [33].	SE YPAPM TEO	5 min.	×1/day.
Bounce at the bell	Teachers were provided with a suggested jump routine (star jumps, tuck jumps) to perform whenever the bell sounded in class (usually for morning break, lunch break and the end of the school day). The jumps were to be performed once the lesson had finished just before leaving the classroom. (Delivery: class teacher)	N/A	Used in a PA school-based intervention for increasing bone strength (no PA outcomes) [34]. Reported as a simple classroom-based exercise without the need for equipment or access to a gym, requiring only 3 min of the school day [35].	SE YPAPM TEO	1–2 min.	×3/day.
Born To Move videos	Videos provided by Les Mills (free access videos available on http://www.lesmillsdemand.com), included instructor led high-intensity motor skills set to contemporary music, designed to improve health-related and skill-related fitness. Videos required hall/gym space with a projector screen connected to an internet enabled device. (Delivery: class teacher)	Daily implementation reduced due to hall/gym accessibility barrier.	Evaluation of BTM pilot programme concluded that live 30-min BTM lessons delivered by a trained instructor engaged children in significantly more MPA than during regular PE [36].	SE YPAPM TEO	10 min.	×2/week.
Daily Mile or 100 Mile Club	Schools planned an outdoor route around school grounds. If the route was smaller than a mile, the number of laps required to achieve the mile was calculated. For the 100 MC, each child received a recording sheet to record miles accumulated. For the DM option, no tracking of distance ran was required. (Delivery: class teacher)	N/A	Short-term follow up results of a study implementing 100 MC in lower-income schoolchildren indicated significant positive effect on ST [37]. The DM is cited by the UK government as an option for schools to deliver PA [10].	SE YPAPM TEO	15 min.	×1/day (DM). ×3/week (100 MC).
Playground activity challenge cards	There were 5 games in total which all included 5 different activity cards. Activities were easy-to-perform exercises designed for children to follow independently without the need for any equipment (apart from a ball in one of the games) or the need for teachers to set up or assist with games. They were placed around the playground in visible places (tied to gates/faces, stuck to classroom windows). (Delivery: child independent / playground staff)	Challenges/games designed for children to follow independently due to teacher barriers cited.		SE YPAPM TEO	5 min per game.	Every recess break.

Table 1. Cont.

PE teacher training	The school sport coach or PE teacher in each intervention school were sent access to an online training session (immediately after intervention allocation, the week prior to the intervention period). The focus of the online content was how to increase high intensity PA and reduce time spent standing still during PE. Access to follow-up support via email was provided. (Delivery: PE teacher)		Supportive, Active (high levels of PA, minimal transition time), Autonomous (opportunity for student choice), Fair, Enjoyable (SAAFE) framework used to guide staff for the planning and delivery of their PE lessons [38]. LET US Play principles also highlighted to staff [39]. Including removing lines, eliminating elimination, reducing team sizes and rethinking space, equipment and rules.	SE YPAPM TEO	N/A	Every PE lesson.
Newsletters	Information relating to PA and its importance for health and wellbeing were sent to schools. Schools were asked to insert messages into their school newsletter which was sent home to all parents (most commonly online via an email or through the school website).	N/A	Use in previous school-based PA interventions as a means for engaging parents [40–42].	SE YPAPM		Weekly/2 weeks (school dependent).
Activity homework	Children received a homework pack which included a letter to parents and 10 different PA challenges. A separate pack of the individual challenges on small pieces of paper were also provided for children to take home if their original pack had been lost at home. Children received a weekly diary to complete whenever they had done PA at home. A blank class chart was provided to populate with names and update every week with school rewards for those who completed the most PA at home.	N/A	Use in previous school-based PA interventions [43,44].	SE YPAPM TEO		Encouraged to be ×1/day.

AB, active break; PA, physical activity; SE, socio-ecological model; YPAPM, youth physical activity promotion model; TEO, theory of expanded, extended, and enhanced opportunities; BTM, born to move; DM, daily mile; 100 MC, 100 mile club; PE, physical education.

2.4 Measures

The primary outcome for this study was school day MVPA. The secondary outcomes were achieving 30 min MVPA during the school day, school day ST, whole weekday ST and PA levels, CRF, and body size (BMI z-score). Measurement protocols at baseline and follow up were the same at both time points and took place within the school grounds. Baseline measures were taken in September 2017, with follow up measures taken in November and December 2017.

2.4.1 Physical Activity

Children wore an ActiGraph GT9X triaxial accelerometer (ActiGraph, Pensacola, FL, USA) which were each initialised to record raw accelerations at a frequency of 100 Hz. Children were instructed to wear the accelerometer for seven days at all times (24 h·day⁻¹), except when engaging in water-based activities such as bathing and swimming. Data was downloaded using ActiLife version 6.11.9 (ActiGraph) and saved in raw format as GT3X files. Raw data files were processed in R (<http://cran.r-project.org>) using GGIR which converted the raw triaxial accelerometer signals into one omnidirectional measure of acceleration termed the Euclidean norm minus one (ENMO; vector magnitude taken from the three axes minus the value of gravity with negative values rounded up to zero) [45,46]. ENMO values were averaged per 1 s epoch over each of the seven monitored days [47]. Accelerometer non-wear was determined using the method of van Hees et al. [45], which has been applied previously in studies involving children [47–49]. Published ENMO prediction equations were used to identify cut-points for classifying activity as MVPA (3 metabolic equivalents (METs; child-specific); 201 mg) [50]. As there is no consensus as to the most appropriate ENMO ST cut-points [51], we also applied the Hildebrand et al. [50] regression equations using 1.5 METs, which resulted in values of 50 mg. Minimum wear time to be included in the analysis was set to 10 h for a minimum of three weekdays at both baseline and follow up [52]. The time periods explored in the analyses included the school day (defined by schools as between the time the timetable begins and the time children are dismissed) and also whole week day (defined as 7 am to 10 pm).

2.4.2 Anthropometrics

Stature was assessed to the nearest 0.1 cm using a portable stadiometer (Leicester Height Measure, Seca, Birmingham, UK). Body mass was assessed to the nearest 0.1 kg (813 scales, Seca). Body weight in kilograms divided by height in meters squared gave the body mass index (BMI) of each participant. BMI z-scores were assigned [53] and age and sex specific BMI cut-points established children as normal weight or overweight/obese (those who were underweight were grouped into the normal weight category) [54]. Waist circumference was measured to the nearest 0.1 cm using an anthropometric tape measure, and the percentage of waist circumference-to-height ratio (%WHtR) was calculated as a measure of central adiposity [55]. Gender-specific equations were used to predict children's age from peak height velocity (APHV), as a proxy measure of biological maturation [56].

2.4.3 Cardiorespiratory Fitness (CRF)

The 20 m multistage shuttle run test was conducted to provide an estimate of CRF [57]. The total number of shuttles completed by each participant was recorded as a proxy measure of CRF. This test has been previously used with children of a similar age to those in the current study [43,58].

2.4.4 Psychological Constructs

A paper questionnaire pack was administered which included eight items measuring PA self-efficacy [59] and 16 items measuring PA enjoyment [60]. All items were scored using a 5-point scale ranging from 1 ("Strongly disagree") to 5 ("Strongly agree"). These questionnaires have previously demonstrated strong factorial validity [59,60].

2.4.5 Socioeconomic Status (SES)

Neighbourhood-level socioeconomic status (SES) was calculated using the 2015 Indices of Multiple Deprivation (IMD) [61]. The IMD is a UK government-produced deprivation measure for England comprising income, employment, health, education, housing, environment, and crime. IMD rank scores were generated from parent-reported home post codes using the National Statistics Postcode Directory database. Every neighbourhood in England is ranked from one (most deprived area) to 32,844 (least deprived area).

2.5. Statistical Analysis

Descriptive statistics (mean and standard deviations) were calculated for the outcomes of all participants at baseline and follow-up. Multilevel modelling was performed using MLwiN Version 2.36 (Centre for Multilevel Modelling, University of Bristol, UK) [62] to determine the effects of the intervention. Multilevel modelling was appropriate for use in this study given the design of children clustered within the seven participating schools. Therefore, a 2-level data structure was used with children defined as the first level of analysis, and schools as the second level of analysis.

Continuous outcome variables were school day ST, light PA (LPA) and MVPA, whole weekday ST, LPA and MVPA, CRF and BMI z-score. The dichotomous outcome variable studied (thus logistic multilevel analysis) was achieving 30 min MVPA/school day. Regression coefficients for the group variables ('0' indicating control schools and '1' indicating intervention schools) reflected between-group differences in the outcome measures (adjusted for baseline values and covariates). Initially, 'crude' interaction analyses were conducted with only the grouping variables and the outcome variable at baseline included in the model [63]. Potential confounding covariates were then added to 'adjusted' models whilst still controlling for baseline outcome variables. These potential confounding covariates were selected based on previous research which has deemed them to be influential to the outcomes and depending on the outcome, included gender [1,64], SES [65,66], body size [67,68], CRF [69,70], PA self-efficacy [31], PA enjoyment [31], accelerometer wear time, and whole weekday ST and MVPA [68,71,72]. Regression coefficients from the models were assessed for significance using the Wald statistic and the following equation, (regression coefficient/standard error)². Statistical significance was set at $p < 0.05$.

The evaluation of potential effect modification was also carried out on several dichotomous covariates (gender, weight status, central obesity risk, and fitness status). These analyses determined whether the intervention effects were different for the subgroups. Interaction terms were added to the models, consisting of a multiplication of the main determinant (intervention) and the potential effect modifier [63]. Due to the reduced power which interaction terms have, statistical significance for this analysis was set at $p < 0.1$ [63].

3. Results

3.1 Preliminary Results

Descriptive statistics are displayed in Table 2 for all participants and by gender, for baseline and follow up measures.

Table 2. Descriptive characteristics of participating children (control and intervention, baseline and follow up; mean (standard deviation) where applicable).

Measure	Baseline					Follow Up				
	Sex	<i>n</i>	Control	<i>n</i>	Intervention	<i>n</i>	Control	<i>n</i>	Intervention	
Stature (cm)	Boy	54	137.5 (7.2)	60	136.9 (5.1)	52	138.6 (7.2)	56	137.7 (4.9)	
	Girl	60	136.7 (6.7)	58	137.8 (6.0)	58	137.5 (6.5)	54	139.0 (6.2)	
	All	114	137.1 (6.9)	118	137.3 (5.5)	110	138.0 (6.8)	110	138.3 (5.6)	
Body mass (kg)	Boy	54	34.9 (8.8)	59	33.7 (6.3)	52	35.9 (8.8)	55	34.0 (6.3)	
	Girl	60	35.2 (8.5)	58	37.1 (8.1)	56	35.7 (9.1)	54	38.0 (8.5)	
	All	114	35.1 (8.6)	117	35.4 (7.4)	108	35.8 (8.9)	109	36.0 (7.7)	
BMI (kg·m ²)	Boy	54	18.3 (3.2)	59	17.9 (2.6)	52	18.5 (3.2)	55	17.8 (2.6)	
	Girl	60	18.7 (3.5)	58	19.5 (3.6)	56	18.7 (3.7)	54	19.6 (3.6)	
	All	114	18.5 (3.3)	117	18.6 (3.2)	108	18.6 (3.5)	109	18.7 (3.3)	
BMI z-score	Boy	53	0.7 (1.2)	56	0.5 (1.1)	51	0.7 (1.1)	53	0.5 (1.0)	
	Girl	60	0.7 (1.3)	57	0.9 (1.2)	56	0.5 (1.2)	53	0.9 (1.2)	
	All	113	0.7 (1.2)	113	0.7 (1.2)	107	0.6 (1.2)	106	0.7 (1.2)	
Overweight/Obese (%)	Boy	53	22.6	56	21.4	51	25.5	53	18.9	
	Girl	60	35.0	57	43.9	56	35.7	53	47.1	
	All	113	29.2	113	32.7	107	30.8	106	33.0	
Waist circumference (cm)	Boy	54	63.7 (9.5)	59	63.5 (7.8)	52	66.7 (9.1)	55	63.8 (6.7)	
	Girl	60	63.7 (9.4)	58	65.9 (8.8)	56	65.1 (10.1)	54	66.1 (8.5)	
	All	114	63.7 (9.4)	117	64.7 (8.3)	108	65.9 (9.6)	109	64.9 (7.7)	
Maturity offset (y)	Boy	51	−3.2 (0.3)	57	−3.3 (0.2)	51	−3.0 (0.4)	54	−3.0 (0.3)	
	Girl	60	−2.2 (0.4)	57	−2.1 (0.3)	57	−1.8 (0.5)	53	−1.8 (0.5)	
	All	111	−2.7 (0.7)	114	−2.7 (0.6)	108	−2.3 (0.7)	107	−2.4 (0.7)	
CRF (Number of shuttles)	Boy	52	36.7 (18.3)	59	33.1 (15.2)	50	34.1 (18.9)	57	36.2 (17.6)	
	Girl	58	28.2 (13.3)	55	25.1 (11.4)	57	25.3 (12.5)	54	25.2 (11.6)	
	All	110	32.3 (16.3)	114	29.2 (14.0)	107	29.4 (16.3)	111	30.9 (15.9)	
IMD Rank	Boy	51	5618.8 (5324.0)	59	6379.4 (7995.8)	N/A		N/A		
	Girl	58	5811.1 (6396.3)	56	8322.6 (8497.7)	N/A		N/A		
	All	109	5721.1 (5892.7)	115	7325.7 (8265.5)	N/A		N/A		

BMI, body mass index; CRF, cardiorespiratory fitness; IMD, indices of multiple deprivation.

3.2 Intervention Effects

Table 3 shows the intervention effects on each outcome. In the adjusted models, time spent engaged in ST during the school day was significantly less for the intervention children compared to the control group (−9.0 min; $p = 0.01$). There were no intervention effects on any of the remaining outcome measures, although the trends for school day PA and CRF were in a favourable direction. The odds of achieving 30 min of MVPA per school day was 2.79 times higher in the intervention group compared to the control group, however this did not reach significance ($p = 0.07$).

Table 3. Multilevel model analyses of the outcome measures.

Outcome Measure	Crude Model ^a			Adjusted Model ^b		
	β or OR	95% CI	<i>p</i>	β or OR	95% CI	<i>p</i>
School day ST	10.1 ^c	-17.8 to -2.4	0.01	-9.0 ^c	-17.7 to -0.2	0.04
School day LPA	4.2 ^c	-1.1 to 9.4	0.1	3.5 ^c	-1.9 to 8.9	0.2
School day total PA	7.1 ^c	-1.1 to 15.2	0.1	5.4 ^c	-2.0 to 12.8	0.2
School day MVPA	1.9 ^c	1.8 to 2.1	0.5	1.5 ^c	-4.0 to 7.0	0.6
30 min MVPA/school day	2.73 ^d	0.36 to 2.20	0.03	2.79 ^d	0.49 to 2.71	0.07
Whole day ST	-0.2 ^c	-23.4 to 22.9	1.0	-2.7 ^c	-25.1 to 19.7	0.8
Whole weekday LPA	-2.7 ^c	-14.2 to 8.8	0.9	-8.8 ^c	-20.3 to 2.7	0.1
Whole weekday total PA	-2.5 ^c	-19.7 to 14.7	0.8	-12.3 ^c	-30.2 to 5.7	0.2
Whole weekday MVPA	-0.9 ^c	-10.5 to 8.7	0.7	-4.1 ^c	-13.9 to 5.7	0.4
CRF	4.9 ^c	0.8 to 8.9	0.02	3.7 ^c	-0.1 to 7.6	0.06
BMI z-score	0.0 ^c	-0.2 to 0.2	0.8	0.0 ^c	-0.2 to 0.2	1.0

Values reflect the intervention effects (i.e., between group differences) between baseline and post intervention. Values in bold denote beta (95% CI) and significance values of outcomes with significant intervention effects ($p < 0.05$). ^a Adjusted for group and baseline value of the outcome measure. ^b Additionally adjusted for confounding covariates. ^c β value. ^d OR. OR, odds ratio; CI, confidence interval; ST, sedentary time; LPA, light physical activity; MVPA, moderate to vigorous physical activity; CRF, cardiorespiratory fitness, BMI, body mass index.

3.3 Sub-Group Analyses

There were no post-intervention interaction effects in any of the dichotomous variables (sex, weight status, central obesity risk, fitness status) on the outcomes of school day ST and PA, whole day ST and PA, BMI z-score, and CRF.

4. Discussion

This study aimed to (1) assess the impact of the AS:Sk multi-component intervention on the primary outcome of school day MVPA, and (2) assess the impact of the AS:Sk multi-component intervention on the secondary outcomes of achieving 30 min MVPA/school day, school day ST, whole weekday ST and PA levels, CRF and body size. Overall, after accounting for confounding variables, the intervention had a significant effect on school day ST which was significantly less for the intervention children by 9 min per day compared to the control group. Trends were observed for favourable changes in school day LPA, PA, MVPA, achieving 30 min school day MVPA, and CRF, however these did not reach significance.

The AS:Sk intervention demonstrates school-based PA components which are novel in their ability to target various time points in the school day with no financial costs to the school. The significant effects that the intervention had on ST are consistent with previous research. For example, the Finnish Schools on the Move study, which allowed schools to plan their own interventions with strategies such as longer recess periods, increased use of equipment during the school day, and staff training, reported decreased ST at 1.5 year follow-up in children similar in age to those in AS:Sk [73]. In contrast, the Active Living multi-component school-based intervention, which used techniques to target PA in school, before, and after school with active transport, and also during leisure time observed a general increase in ST at 12 months follow-up (2.2% more daily time spent in sedentary behaviour), which the authors speculated could have been due to the participants increase in age [25]. Given the short follow up period in the current study, it is difficult to establish whether the initial positive impact on ST would be sustained long term, inhibiting the anticipated age-related increase. Project timescale and subsequent funding precluded the utilisation of a longer-term intervention period and follow up evaluations.

A significant intervention effect on school day ST has implications for both public health policy and child health outcomes. Public health guidelines in both the UK and other countries recommend that overall sedentary time should be limited in children and young people [12–14]. Moreover,

research has explored the relationship between ST and health indicators, subsequently highlighting the detrimental effects that ST can have on child health. For example, time spent being sedentary is positively associated with BMI z-score, and negatively associated with fitness in children and youth (aged 6–17 years) [74].

Results indicated a modest and non-significant increase in school day MVPA of 1.5 min. Sutherland and colleagues also reported modest increases in MVPA after the implementation of their multi-component school-based programme, 'PA 4 Everyone' [41]. Differences to control students were significant, with 3.9 more minutes of MVPA per day accumulated by intervention students [41]. Conversely, the 'Active Living' multicomponent school-based PA intervention had no significant effect on MVPA per day and saw a general reduction in PA [25].

The addition of even small amounts of MVPA to the school day may be beneficial to physical health, particularly when compared to interventions which see negative outcomes and also when the age-related decline in MVPA is considered [75]. However, the meaningfulness of potential benefits could be questioned. The addition of MVPA does predict positive effects with decreased adiposity, whilst the replacement of MVPA with any other movement behaviour predicts negative effects with higher adiposity and lower CRF [76,77]. However, these results are based on 15 min reallocations of time which is considerably more than the intervention effect on MVPA in the current study. Researchers and practitioners should focus on developing sustainable strategies for increasing MVPA participation during the school day given its significant importance for physical health. Understanding how interventions are implemented within schools from the perspective of teachers and students alike, may help in the development of successful school-based techniques. The process evaluation of interventions is advocated by the UK Medical Research Council (MRC) and can play a crucial role in understanding and learning from findings [78,79]. Despite this, implementation data are rarely reported in the literature and a lack of standardised definitions and measurements of implementation contributes to this [79]. A review into the barriers and facilitators to the implementation of PA policies in schools concluded that the body of literature surrounding this topic area from a theoretical perspective was scarce [80]. Implementation of PA in the classroom setting has received more coverage in the literature recently, including perspectives from teachers which has provided useful and important considerations for future interventions [81,82].

There were no significant intervention effects on whole weekday movement behaviours (including out of school hours). A previous systematic review concluded that school-based interventions had no effect on leisure time PA [83]. Whilst results were not significant, intervention effects on whole weekday PA were in the negative direction. This could suggest that children compensated for the increased PA opportunities they were provided with during the school day by decreasing their leisure time PA. This theory has also been suggested by previous interventions in which increases in school day MVPA did not translate into positive effects across the day [73]. An intervention which increased the number of compulsory PE lessons found that the percentage of time spent in MVPA during school was greater; however, the percentage of time spent in MVPA out of school was lower when both time periods were compared to normal schools [84]. Further PA compensation research has also suggested that for every additional 10 min spent in MVPA, children engaged in 5 min less the following day [85]. That being said, not all interventions report compensation effects, for example a review of school-based interventions found five in total which were effective at increasing overall PA [86]. AS! BC is one of these interventions that was effective at increasing overall PA [87]. Activities implemented across six action zones in this intervention included extracurricular and family and community, these zones in particular may have been the important factor which limited PA compensation outside of the school day [87].

The CSPAP approach to PA promotion comprises of five different components or points of intervention which includes PA before and after school [15]. Whilst attempts were made to target the out of school period with the PA homework component of the AS:Sk intervention it would appear that more substantial efforts are needed, for example with school-based extracurricular PA opportunities,

rather than PA that requires children to engage with in the home environment. Many barriers to participation in out of school PA exist, including parental reported barriers such as safety concerns [88]. Screen time has also been reported by parents as a barrier, particularly as it is seen as the 'norm' for children to engage and therefore parents struggle to limit it [88,89]. Parents have reported that engagement in family-based PA intervention programmes would be the most effective way to increase their child's PA [88]. The out of school time period for PA participation requires more attention, even from interventions which are primarily designed as school-based, in which the out of school barriers to PA participation and the desired family-based sessions should be considered.

The AS:Sk intervention had several strengths. Firstly, it was developed through prior formative research and was theoretically underpinned by conceptual behaviour change models [17,26,31]. This approach adheres to MRC guidelines for the development of complex interventions [90]. In addition, school staff were provided with the flexibility to implement the PA components when it best suited their class or school. This approach is most feasible in the "real-world" school setting in which unpredictable changes to timetables can happen, thus programme flexibility has previously been reported by teachers as a facilitator to implementation [19]. There was also no financial cost to the schools or the project. This would suggest that the intervention can be self-sustained by schools alone and, therefore, has potential for long-term implementation, although the teacher burden relating to planning and implementation should not be understated. The use of objectively measured PA to assess the intervention effect is an important strength of the study. Furthermore, the use of raw accelerations avoids the uncertainty of pre-processed data such as counts and the possibility that signal-filtering methods alter study results [91,92]. A limitation of the study is the modest sample size, which may have resulted in a lack of power in the statistical test outcomes, particularly the positive outcomes which did not reach statistical significance. The number of children who met the accelerometer wear-time criteria at both baseline and follow up measures also impacted on the final sample size. A further limitation was the timing of the follow up measures in both control and intervention schools. By necessity, measures were taken at an atypical school period, in the final few weeks before Christmas. It is in this period that school timetables are often disregarded and festive activities sometimes replace usual practice. Thus, the activity of children may not be representative of the rest of the school year. Intervention schools in particular may not have implemented the intervention in these final school weeks as they may have done so earlier in the school term. Furthermore, given that intervention implementation was sustained by school staff only, without any external support, it is likely that there were differences in implementation between participating schools. Gaining an accurate and objective record of implementation frequency across the eight-week period within each participating school may require daily researcher visits during the intervention period, which was not possible due to the time constraints of the research staff. Alternatively, teacher logs could be used, but these may be more subject to bias. Quantitative data to illustrate implementation frequency across the eight-week period was, therefore, not available, and it is acknowledged that differences in implementation frequency between schools likely impacted the results. The lack of a more long-term follow up measurement period was also a limitation. Given that follow up measurements were taken only eight weeks after implementation it is difficult to understand the sustainability of the intervention. The overall short intervention implementation period of eight weeks is also a weakness of the study, as interventions of longer duration have been shown to be more effective [86].

5. Conclusions

The AS:Sk multi-component school-based PA intervention had a significant positive effect on school day ST. There were no significant intervention effects on any of the other outcome measures. The small sample size of the current study was an important limitation within the study and may have contributed to the analyses lacking power. The school day period should continue to be a priority. Its importance for PA participation has previously been highlighted, and this study indicates that

positive effects on ST in particular are achievable across the school day. Modifications to out-of-school components would be beneficial to avoid any compensation effects on PA participation. The AS:Sk intervention has potential to be scaled up to a full trial following modifications based on the results of this pilot study. Future research should focus on exploring ways in which MVPA participation can be increased during the school day. This may be with the development of appropriate school-based techniques or, conversely, focusing on how to improve the implementation of established techniques (such as the components of the current intervention) through process evaluation research.

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References

1. Cooper, A.R.; Goodman, A.; Page, A.S.; Sherar, L.B.; Esliger, D.W.; van Sluijs, E.M.; Andersen, L.B.; Anderssen, S.; Cardon, G.; Davey, R.; et al. Objectively measured physical activity and sedentary time in youth: The International children's accelerometry database (ICAD). *Int. J. Behav. Nutr. Phys. Act.* **2015**, *12*, 113. [\[CrossRef\]](#) [\[PubMed\]](#)
2. Hallal, P.C.; Andersen, L.B.; Bull, F.C.; Guthold, R.; Haskell, W.; Ekelund, U. Global physical activity levels: Surveillance progress, pitfalls, and prospects. *Lancet* **2012**, *380*, 247–257. [\[CrossRef\]](#)
3. Poitras, V.J.; Gray, C.E.; Borghese, M.M.; Carson, V.; Chaput, J.P.; Janssen, I.; Katzmarzyk, P.T.; Pate, R.R.; Connor Gorber, S.; Kho, M.E.; et al. Systematic review of the relationships between objectively measured physical activity and health indicators in school-aged children and youth. *Appl. Physiol. Nutr. Metab.* **2016**, *41* (Suppl. 3), S197–S239. [\[CrossRef\]](#) [\[PubMed\]](#)
4. Lubans, D.; Richards, J.; Hillman, C.; Faulkner, G.; Beauchamp, M.; Nilsson, M.; Kelly, P.; Smith, J.; Raine, L.; Biddle, S. Physical Activity for Cognitive and Mental Health in Youth: A Systematic Review of Mechanisms. *Pediatrics* **2016**, *138*, e20161642. [\[CrossRef\]](#) [\[PubMed\]](#)
5. Reddon, H.; Meyre, D.; Cairney, J. Physical Activity and Global Self-worth in a Longitudinal Study of Children. *Med. Sci. Sports Exerc.* **2017**, *49*, 1606–1613. [\[CrossRef\]](#) [\[PubMed\]](#)
6. Pearson, N.; Haycraft, E.; Johnston, J.P.; Atkin, A.J. Sedentary behaviour across the primary-secondary school transition: A systematic review. *Prev. Med.* **2017**, *94*, 40–47. [\[CrossRef\]](#) [\[PubMed\]](#)
7. Carson, V.; Hunter, S.; Kuzik, N.; Gray, C.E.; Poitras, V.J.; Chaput, J.P.; Saunders, T.J.; Katzmarzyk, P.T.; Okely, A.D.; Connor Gorber, S. Systematic review of sedentary behaviour and health indicators in school-aged children and youth: An update. *Appl. Physiol. Nutr. Metab.* **2016**, *41*, S240–S265. [\[CrossRef\]](#) [\[PubMed\]](#)
8. Hesketh, K.R.; Lakshman, R.; van Sluijs, E.M.F. Barriers and facilitators to young children's physical activity and sedentary behaviour: A systematic review and synthesis of qualitative literature. *Obes. Rev.* **2017**, *18*, 987–1017. [\[CrossRef\]](#) [\[PubMed\]](#)
9. Burns, R.D.; Fu, Y.; Podlog, L.W. School-based physical activity interventions and physical activity enjoyment: A meta-analysis. *Prev. Med.* **2017**, *103*, 84–90. [\[CrossRef\]](#) [\[PubMed\]](#)
10. *Childhood Obesity: A Plan for Action*; HM Government: London, UK, 2016.
11. Medicine, I.O. (Ed.) *Educating the Student Body: Taking Physical Activity and Physical Education to School*; The National Academies Press: Washington, DC, USA, 2013.
12. Chief Medical Officer Department of Health. *Start Active, Stay Active: A Report on Physical Activity from the Four Home Countries*; Department of Health: London, UK, 2011.
13. Tremblay, M.S.; Carson, V.; Chaput, J.P.; Connor Gorber, S.; Dinh, T.; Duggan, M.; Faulkner, G.; Gray, C.E.; Gruber, R.; Janson, K.; et al. Canadian 24-Hour Movement Guidelines for Children and Youth: An Integration of Physical Activity, Sedentary Behaviour, and Sleep. *Appl. Physiol. Nutr. Metab.* **2016**, *41* (Suppl. 3), S311–S327. [\[CrossRef\]](#) [\[PubMed\]](#)
14. *Physical Activity Guidelines 2017*; Health Council of the Netherlands: The Hague, The Netherlands, 2017.
15. Erwin, H.; Beighle, A.; Carson, R.L.; Castelli, D.M. Comprehensive School-Based Physical Activity

- Promotion: A Review. *Quest* **2013**, *65*, 412–428. [[CrossRef](#)]
16. Russ, L.B.; Webster, C.A.; Beets, M.W.; Phillips, D.S. Systematic Review and Meta-Analysis of Multi-Component Interventions Through Schools to Increase Physical Activity. *J. Phys. Act. Health* **2015**, *12*, 1436–1446. [[CrossRef](#)] [[PubMed](#)]
17. Kenneth, R.M.; Daniel, B.; Allan, S.; Karen, G. An Ecological Perspective on Health Promotion Programs. *Health Educ. Q.* **1988**, *15*, 351–377.
18. Naylor, P.-J.; Macdonald, H.M.; Reed, K.E.; McKay, H.A. Action Schools! BC: A Socioecological Approach to Modifying Chronic Disease Risk Factors in Elementary School Children. *Prev. Chronic Dis.* **2006**, *3*, A60. [[PubMed](#)]
19. Naylor, P.-J.; Macdonald, H.M.; Zebedee, J.A.; Reed, K.E.; McKay, H.A. Lessons learned from Action Schools! BC – An ‘active school’ model to promote physical activity in elementary schools. *J. Sci. Med. Sport* **2006**, *9*, 413–423. [[CrossRef](#)] [[PubMed](#)]
20. Kellou, N.; Sandalinas, F.; Copin, N.; Simon, C. Prevention of unhealthy weight in children by promoting physical activity using a socio-ecological approach: What can we learn from intervention studies? *Diabetes Metab.* **2014**, *40*, 258–271. [[CrossRef](#)] [[PubMed](#)]
21. Murillo Pardo, B.; García Bengoechea, E.; Generelo Lanaspá, E.; Bush, P.L.; Zaragoza Casterad, J.; Julián Clemente, J.A.; García González, L. Promising school-based strategies and intervention guidelines to increase physical activity of adolescents. *Health Educ. Res.* **2013**, *28*, 523–538. [[CrossRef](#)] [[PubMed](#)]
22. Van Sluijs, E.M.F.; McMinn, A.M.; Griffin, S.J. Effectiveness of interventions to promote physical activity in children and adolescents: Systematic review of controlled trials. *BMJ* **2007**, *335*, 703–707. [[CrossRef](#)] [[PubMed](#)]
23. Owen, M.B.; Curry, W.B.; Kerner, C.; Newson, L.; Fairclough, S.J. The effectiveness of school-based physical activity interventions for adolescent girls: A systematic review and meta-analysis. *Prev. Med.* **2017**, *105*, 237–249. [[CrossRef](#)] [[PubMed](#)]
24. Okely, A.D.; Lubans, D.R.; Morgan, P.J.; Cotton, W.; Peralta, L.; Miller, J.; Batterham, M.; Janssen, X. Promoting physical activity among adolescent girls: The Girls in Sport group randomized trial. *Int. J. Behav. Nutr. Phys. Act.* **2017**, *14*, 81. [[CrossRef](#)] [[PubMed](#)]
25. Van Kann, D.H.; Kremers, S.P.; de Vries, N.K.; de Vries, S.I.; Jansen, M.W. The effect of a school-centered multicomponent intervention on daily physical activity and sedentary behavior in primary school children: The Active Living study. *Prev. Med.* **2016**, *89*, 64–69. [[CrossRef](#)] [[PubMed](#)]
26. Beets, M.W.; Okely, A.; Weaver, R.G.; Webster, C.; Lubans, D.; Brusseau, T.; Carson, R.; Cliff, D.P. The theory of expanded, extended, and enhanced opportunities for youth physical activity promotion. *Int. J. Behav. Nutr. Phys. Act.* **2016**, *13*, 120. [[CrossRef](#)] [[PubMed](#)]
27. Collins, S. *Seven Wards: A Focus on Skelmersdale*; Lancashire, C.C., Ed.; Lancashire County Council: Preston, UK, 2015.
28. Hemming, K.; Girling, A.J.; Sitch, A.J.; Marsh, J.; Lilford, R.J. Sample size calculations for cluster randomised controlled trials with a fixed number of clusters. *BMC Med. Res. Methodol.* **2011**, *11*, 102. [[CrossRef](#)] [[PubMed](#)]
29. Taylor, S.L.; Curry, W.B.; Knowles, Z.R.; Noonan, R.J.; McGrane, B.; Fairclough, S.J. Predictors of Segmented School Day Physical Activity and Sedentary Time in Children from a Northwest England Low-Income Community. *Int. J. Environ. Res. Public Health* **2017**, *14*, E534. [[CrossRef](#)] [[PubMed](#)]
30. Campbell, M.K.; Piaggio, G.; Elbourne, D.R.; Altman, D.G. Consort 2010 statement: Extension to cluster randomised trials. *BMJ* **2012**, *345*, e5661. [[CrossRef](#)] [[PubMed](#)]
31. Welk, G.J. The Youth Physical Activity Promotion Model: A Conceptual Bridge Between Theory and Practice. *Quest* **1999**, *51*, 5–23. [[CrossRef](#)]
32. Watson, A.; Timperio, A.; Brown, H.; Hesketh, K.D. A primary school active break programme (ACTI-BREAK): Study protocol for a pilot cluster randomised controlled trial. *Trials* **2017**, *18*, 433. [[CrossRef](#)] [[PubMed](#)]
33. Carlson, J.A.; Engelberg, J.K.; Cain, K.L.; Conway, T.L.; Mignano, A.M.; Bonilla, E.A.; Geremia, C.; Sallis, J.F. Implementing classroom physical activity breaks: Associations with student physical activity and classroom behavior. *Prev. Med.* **2015**, *81*, 67–72. [[CrossRef](#)] [[PubMed](#)]
34. McKay, H.; MacLean, L.; Petit, M.; MacKelvie-O’Brien, K.; Janssen, P.; Beck, T.; Khan, K. “Bounce at the Bell”: A novel program of short bouts of exercise improves proximal femur bone mass in early pubertal children. *Br. J. Sports Med.* **2005**, *39*, 521–526. [[CrossRef](#)] [[PubMed](#)]
35. Macdonald, H.M.; Kontulainen, S.A.; Khan, K.M.; McKay, H.A. Is a school-based physical activity intervention effective for increasing tibial bone strength in boys and girls? *J. Bone Miner. Res. Off. J. Am. Soc. Bone Miner. Res.* **2007**, *22*, 434–446. [[CrossRef](#)] [[PubMed](#)]
36. Fairclough, S.J.; McGrane, B.; Sanders, G.; Taylor, S.; Owen, M.; Curry, W. A non-equivalent group pilot trial of a school-based physical activity and fitness intervention for 10–11 year old english children: Born to move. *BMC Public Health* **2016**, *16*, 861. [[CrossRef](#)] [[PubMed](#)]
37. Sacke, J.M.; Wright, C.; Amin, S.; Anzman-Frasca, S.; Chomitz, V.; Chui, K.; Nelson, M.; Economos, C.

- The Fueling Learning Through Exercise (FLEX) Study: Short-term Findings On Sedentary Time In Lower-income Schoolchildren. *May 31 445 PM–500 PM. Med. Sci. Sports Exerc.* **2017**, *49*, 200–201. [[CrossRef](#)]
38. Lubans, D.R.; Lonsdale, C.; Cohen, K.; Eather, N.; Beauchamp, M.R.; Morgan, P.J.; Sylvester, B.D.; Smith, J.J. Framework for the design and delivery of organized physical activity sessions for children and adolescents: Rationale and description of the ‘SAAFE’ teaching principles. *Int. J. Behav. Nutr. Phys. Act.* **2017**, *14*, 24. [[CrossRef](#)] [[PubMed](#)]
39. Brazendale, K.; Chandler, J.L.; Beets, M.W.; Weaver, R.G.; Beighle, A.; Huberty, J.L.; Moore, J.B. Maximizing children’s physical activity using the LET US Play principles. *Prev. Med.* **2015**, *76*, 14–19. [[CrossRef](#)] [[PubMed](#)]
40. Lubans, D.R.; Morgan, P.J.; Weaver, K.; Callister, R.; Dewar, D.L.; Costigan, S.A.; Finn, T.L.; Smith, J.; Upton, L.; Plotnikoff, R.C. Rationale and study protocol for the supporting children’s outcomes using rewards, exercise and skills (SCORES) group randomized controlled trial: A physical activity and fundamental movement skills intervention for primary schools in low-income communities. *BMC Public Health* **2012**, *12*, 427.
41. Sutherland, R.; Campbell, E.; Lubans, D.R.; Morgan, P.J.; Okely, A.D.; Nathan, N.; Wolfenden, L.; Wiese, J.; Gillham, K.; Hollis, J.; et al. ‘Physical Activity 4 Everyone’ school-based intervention to prevent decline in adolescent physical activity levels: 12 month (mid-intervention) report on a cluster randomised trial. *Br. J. Sports Med.* **2016**, *50*, 488–495. [[CrossRef](#)] [[PubMed](#)]
42. Vander Ploeg, K.A.; Maximova, K.; McGavock, J.; Davis, W.; Veugelers, P. Do school-based physical activity interventions increase or reduce inequalities in health? *Soc. Sci. Med.* **2014**, *112*, 80–87. [[CrossRef](#)] [[PubMed](#)]
43. Fairclough, S.J.; Hackett, A.F.; Davies, I.G.; Gobbi, R.; Mackintosh, K.A.; Warburton, G.L.; Stratton, G.; van Sluijs, E.M.F.; Boddy, L.M. Promoting healthy weight in primary school children through physical activity and nutrition education: A pragmatic evaluation of the CHANGE! randomised intervention study. *BMC Public Health* **2013**, *13*, 626. [[CrossRef](#)] [[PubMed](#)]
44. Kriemler, S.; Zahner, L.; Schindler, C.; Meyer, U.; Hartmann, T.; Hebestreit, H.; Brunner-La Rocca, H.P.; van Mechelen, W.; Puder, J.J. Effect of school based physical activity programme (KISS) on fitness and adiposity in primary schoolchildren: Cluster randomised controlled trial. *BMJ* **2010**, *340*, c785. [[CrossRef](#)] [[PubMed](#)]
45. Van Hees, V.T.; Gorzelniak, L.; Dean Leon, E.C.; Eder, M.; Pias, M.; Taherian, S.; Ekelund, U.; Renstrom, F.; Franks, P.W.; Horsch, A.; et al. Separating movement and gravity components in an acceleration signal and implications for the assessment of human daily physical activity. *PLoS ONE* **2013**, *8*, e61691. [[CrossRef](#)] [[PubMed](#)]
46. Van Hees, V.T.; Fang, Z.; Langford, J.; Assah, F.; Mohammad, A.; da Silva, I.C.M.; Trenell, M.I.; White, T.; Wareham, N.J.; Brage, S. Autocalibration of accelerometer data for free-living physical activity assessment using local gravity and temperature: An evaluation on four continents. *J. Appl. Physiol.* **2014**, *117*, 738–744. [[CrossRef](#)] [[PubMed](#)]
47. Fairclough, S.J.; Noonan, R.; Rowlands, A.V.; Van Hees, V.; Knowles, Z.; Boddy, L.M. Wear Compliance and Activity in Children Wearing Wrist- and Hip-Mounted Accelerometers. *Med. Sci. Sports Exerc.* **2016**, *48*, 245–253. [[CrossRef](#)] [[PubMed](#)]
48. Rowlands, A.V.; Cliff, D.P.; Fairclough, S.J.; Boddy, L.M.; Olds, T.S.; Parfitt, G.; Noonan, R.J.; Downs, S.J.; Knowles, Z.R.; Beets, M.W. Moving Forward with Backward Compatibility: Translating Wrist Accelerometer Data. *Med. Sci. Sports Exerc.* **2016**, *48*, 2142–2149. [[CrossRef](#)] [[PubMed](#)]
49. Noonan, R.J.; Boddy, L.M.; Kim, Y.; Knowles, Z.R.; Fairclough, S.J. Comparison of children’s free-living physical activity derived from wrist and hip raw accelerations during the segmented week. *J. Sports Sci.* **2017**, *35*, 2067–2072. [[CrossRef](#)] [[PubMed](#)]
50. Hildebrand, M.; van Hees, V.T.; Hansen, B.H.; Ekelund, U.L.F. Age Group Comparability of Raw Accelerometer Output from Wrist- and Hip-Worn Monitors. *Med. Sci. Sports Exerc.* **2014**, *46*, 1816–1824. [[CrossRef](#)] [[PubMed](#)]
51. Hildebrand, M.; Hansen, B.H.; van Hees, V.T.; Ekelund, U. Evaluation of raw acceleration sedentary thresholds in children and adults. *Scand. J. Med. Sci. Sports* **2017**, *27*, 1814–1823. [[CrossRef](#)] [[PubMed](#)]
52. Rich, C.; Geraci, M.; Griffiths, L.; Sera, F.; Dezauteux, C.; Cortina-Borja, M. Quality Control Methods in Accelerometer Data Processing: Defining Minimum Wear Time. *PLoS ONE* **2013**, *8*, e67206. [[CrossRef](#)] [[PubMed](#)]
53. Cole, T.J.; Freeman, J.V.; Preece, M.A. Body mass index reference curves for the UK, 1990. *Arch. Dis. Child.* **1995**, *73*, 25–29. [[CrossRef](#)] [[PubMed](#)]
54. Cole, T.J.; Bellizzi, M.C.; Flegal, K.M.; Dietz, W.H. Establishing a standard definition for child overweight and obesity worldwide: International survey. *BMJ* **2000**, *320*, 1240. [[CrossRef](#)] [[PubMed](#)]
55. Mehta, S.K. Waist circumference to height ratio in children and adolescents. *Clin. Pediatr.* **2015**, *54*, 652–658. [[CrossRef](#)] [[PubMed](#)]
56. Moore, S.A.; McKay, H.A.; Macdonald, H.; Nettlefold, L.; Baxter-Jones, A.D.; Cameron, N.; Brasher, P.M.

- Enhancing a Somatic Maturity Prediction Model. *Med. Sci. Sports Exerc.* **2015**, *47*, 1755–1764. [[CrossRef](#)] [[PubMed](#)]
57. Léger, L.A.; Mercier, D.; Gadoury, C.; Lambert, J. The multistage 20 metre shuttle run test for aerobic fitness. *J. Sports Sci.* **1988**, *6*, 93–101. [[CrossRef](#)] [[PubMed](#)]
58. Boddy, L.M.; Fairclough, S.J.; Atkinson, G.; Stratton, G. Changes in cardiorespiratory fitness in 9- to 10.9-year-old children: SportsLinX 1998–2010. *Med. Sci. Sports Exerc.* **2012**, *44*, 481–486. [[CrossRef](#)] [[PubMed](#)]
59. Motl, R.W.; Dishman, R.K.; Trost, S.G.; Saunders, R.P.; Dowda, M.; Felton, G.; Ward, D.S.; Pate, R.R. Factorial Validity and Invariance of Questionnaires Measuring Social-Cognitive Determinants of Physical Activity among Adolescent Girls. *Prev. Med.* **2000**, *31*, 584–594. [[CrossRef](#)] [[PubMed](#)]
60. Motl, R.W.; Dishman, R.K.; Saunders, R.; Dowda, M.; Felton, G.; Pate, R.R. Measuring enjoyment of physical activity in adolescent girls. *Am. J. Prev. Med.* **2001**, *21*, 110–117. [[CrossRef](#)]
61. *The English Indices of Deprivation 2015*; Ministry of Housing, Communities & Local Government: Wetherby, UK, 2015.
62. Rabesh, J.; Charlton, C.; Browne, W.J.; Healy, M.; Cameron, B. *MLwiN Version 2.10*; Centre for Multilevel Modelling, University of Bristol: Bristol, UK, 2009.
63. Twisk, J.W.R. *Applied Multilevel Analysis*; Cambridge University Press: Cambridge, UK, 2006.
64. Zaquout, M.; Vyncke, K.; Moreno, L.A.; De Miguel-Etayo, P.; Lauria, F.; Molnar, D.; Lissner, L.; Hunsberger, M.; Veidebaum, T.; Tornaritis, M.; et al. Determinant factors of physical fitness in European children. *Int. J. Public Health* **2016**, *61*, 573–582. [[CrossRef](#)] [[PubMed](#)]
65. Baquet, G.; Ridgers, N.D.; Blaes, A.; Aucouturier, J.; Van Praagh, E.; Berthoin, S. Objectively assessed recess physical activity in girls and boys from high and low socioeconomic backgrounds. *BMC Public Health* **2014**, *14*, 192. [[CrossRef](#)] [[PubMed](#)]
66. Borraccino, A.; Lemma, P.; Iannotti, R.J.; Zambon, A.; Dalmasso, P.; Lazzeri, G.; Giacchi, M.; Cavallo, F. Socioeconomic effects on meeting physical activity guidelines: Comparisons among 32 countries. *Med. Sci. Sports Exerc.* **2009**, *41*, 749–756. [[CrossRef](#)] [[PubMed](#)]
67. Richmond, R.C.; Davey Smith, G.; Ness, A.R.; den Hoed, M.; McMahon, G.; Timpson, N.J. Assessing Causality in the Association between Child Adiposity and Physical Activity Levels: A Mendelian Randomization Analysis. *PLoS Med.* **2014**, *11*, e1001618. [[CrossRef](#)] [[PubMed](#)]
68. Santos, R.; Mota, J.; Okely, A.D.; Pratt, M.; Moreira, C.; Coelho-e-Silva, M.J.; Vale, S.; Sardinha, L.B. The independent associations of sedentary behaviour and physical activity on cardiorespiratory fitness. *Br. J. Sports Med.* **2014**, *48*, 1508–1512. [[CrossRef](#)] [[PubMed](#)]
69. Grund, A.; Dilba, B.; Forberger, K.; Krause, H.; Siewers, M.; Rieckert, H.; Müller, M.J. Relationships between physical activity, physical fitness, muscle strength and nutritional state in 5- to 11-year-old children. *Eur. J. Appl. Physiol.* **2000**, *82*, 425–438. [[CrossRef](#)] [[PubMed](#)]
70. Silva, G.; Andersen, L.B.; Aires, L.; Mota, J.; Oliveira, J.; Ribeiro, J.C. Associations between sports participation, levels of moderate to vigorous physical activity and cardiorespiratory fitness in children and adolescents. *J. Sports Sci.* **2013**, *31*, 1359–1367. [[CrossRef](#)] [[PubMed](#)]
71. Mann, K.D.; Howe, L.D.; Basterfield, L.; Parkinson, K.N.; Pearce, M.S.; Reilly, J.K.; Adamson, A.J.; Reilly, J.J.; Janssen, X. Longitudinal study of the associations between change in sedentary behavior and change in adiposity during childhood and adolescence: Gateshead Millennium Study. *Int. J. Obes.* **2017**, *41*, 1042–1047. [[CrossRef](#)] [[PubMed](#)]
72. Wilkie, H.J.; Standage, M.; Gillison, F.B.; Cumming, S.P.; Katzmarzyk, P.T. Correlates of intensity-specific physical activity in children aged 9–11 years: A multilevel analysis of UK data from the International Study of Childhood Obesity, Lifestyle and the Environment. *BMJ Open* **2018**, *8*, e018373. [[CrossRef](#)] [[PubMed](#)]
73. Haapala, H.L.; Hirvensalo, M.H.; Kulmala, J.; Hakonen, H.; Kankaanpää, A.; Laine, K.; Laakso, L.; Tammelin, T.H. Changes in physical activity and sedentary time in the Finnish Schools on the Move program: A quasi-experimental study. *Scand. J. Med. Sci. Sports* **2017**, *27*, 1442–1453. [[CrossRef](#)] [[PubMed](#)]
74. Carson, V.; Tremblay, M.S.; Chaput, J.P.; Chastin, S.F. Associations between sleep duration, sedentary time, physical activity, and health indicators among Canadian children and youth using compositional analyses. *Appl. Physiol. Nutr. Metab.* **2016**, *41* (Suppl. 3), S294–S302. [[CrossRef](#)] [[PubMed](#)]
75. Dumith, S.C.; Gigante, D.P.; Domingues, M.R.; Kohl, H.W. Physical activity change during adolescence: A systematic review and a pooled analysis. *Int. J. Epidemiol.* **2011**, *40*, 685–698. [[CrossRef](#)] [[PubMed](#)]
76. Dumuid, D.; Stanford, T.E.; Pedišić, Ž.; Maher, C.; Lewis, L.K.; Martín-Fernández, J.-A.; Katzmarzyk, P.T.; Chaput, J.-P.; Fogelholm, M.; Standage, M.; et al. Adiposity and the isothermal substitution of physical activity, sedentary time and sleep among school-aged children: A compositional data analysis approach. *BMC Public Health* **2018**, *18*, 311. [[CrossRef](#)] [[PubMed](#)]
77. Fairclough, S.J.; Dumuid, D.; Taylor, S.; Curry, W.; McGrane, B.; Stratton, G.; Maher, C.; Olds, T. Fitness, fatness and the reallocation of time between children's daily movement behaviours: An analysis of compositional data. *Int. J. Behav. Nutr. Phys. Act.* **2017**, *14*, 64. [[CrossRef](#)] [[PubMed](#)]

78. Moore, G.F.; Audrey, S.; Barker, M.; Bond, L.; Bonell, C.; Hardeman, W. Process evaluation of complex interventions: Medical Research Council guidance. *BMJ* **2015**, *350*, h1258. [[CrossRef](#)] [[PubMed](#)]
79. Naylor, P.J.; Nettlefold, L.; Race, D.; Hoy, C.; Ashe, M.C.; Wharf Higgins, J.; McKay, H.A. Implementation of school based physical activity interventions: A systematic review. *Prev. Med.* **2015**, *72*, 95–115. [[CrossRef](#)] [[PubMed](#)]
80. Nathan, N.; Elton, B.; Babic, M.; McCarthy, N.; Sutherland, R.; Presseau, J.; Seward, K.; Hodder, R.; Booth, D.; Yoong, S.L.; et al. Barriers and facilitators to the implementation of physical activity policies in schools: A systematic review. *Prev. Med.* **2018**, *107*, 45–53. [[CrossRef](#)] [[PubMed](#)]
81. Routen, A.C.; Johnston, J.P.; Glazebrook, C.; Sherar, L.B. Teacher perceptions on the delivery and implementation of movement integration strategies: The CLASS PAL (Physically Active Learning) Programme. *Int. J. Educ. Res.* **2018**, *88*, 48–59. [[CrossRef](#)]
82. Dyrstad, S.M.; Kvalø, S.E.; Alstveit, M.; Skage, I. Physically active academic lessons: Acceptance, barriers and facilitators for implementation. *BMC Public Health* **2018**, *18*, 322. [[CrossRef](#)] [[PubMed](#)]
83. Dobbins, M.; De Corby, K.; Robeson, P.; Husson, H.; Tirilis, D. School-based physical activity programs for promoting physical activity and fitness in children and adolescents aged 6–18. *Cochrane Database Syst. Rev.* **2009**, *28*, CD007651.
84. Møller, N.C.; Tarp, J.; Kamelarczyk, E.F.; Brønd, J.C.; Klakk, H.; Wedderkopp, N. Do extra compulsory physical education lessons mean more physically active children—Findings from the childhood health, activity, and motor performance school study Denmark (The CHAMPS-study DK). *Int. J. Behav. Nutr. Phys. Act.* **2014**, *11*, 121. [[CrossRef](#)] [[PubMed](#)]
85. Ridgers, N.D.; Timperio, A.; Cerin, E.; Salmon, J.O. Compensation of Physical Activity and Sedentary Time in Primary School Children. *Med. Sci. Sports Exerc.* **2014**, *46*, 1564–1569. [[CrossRef](#)] [[PubMed](#)]
86. Kriemler, S.; Meyer, U.; Martin, E.; Sluijs, E.M.; Andersen, L.B.; Martin, B.W. Effect of school-based interventions on physical activity and fitness in children and adolescents: A review of reviews and systematic update. *Br. J. Sports Med.* **2011**, *45*, 923–930. [[CrossRef](#)] [[PubMed](#)]
87. Naylor, P.J.; Macdonald, H.M.; Warburton, D.E.R.; Reed, K.E.; McKay, H.A. An active school model to promote physical activity in elementary schools: Action schools! BC. *Br. J. Sports Med.* **2008**, *42*, 338–343. [[CrossRef](#)] [[PubMed](#)]
88. Noonan, R.J.; Boddy, L.M.; Fairclough, S.J.; Knowles, Z.R. Parental perceptions on childrens out-of-school physical activity and family-based physical activity. *Early Child Dev. Care* **2017**, *187*, 1909–1924. [[CrossRef](#)]
89. Solomon-Moore, E.; Matthews, J.; Reid, T.; Toumpakari, Z.; Sebire, S.J.; Thompson, J.L.; Lawlor, D.A.; Jago, R. Examining the challenges posed to parents by the contemporary screen environments of children: A qualitative investigation. *BMC Pediatr.* **2018**, *18*, 129. [[CrossRef](#)] [[PubMed](#)]
90. Craig, P.; Dieppe, P.; Macintyre, S.; Michie, S.; Nazareth, I.; Petticrew, M. Developing and evaluating complex interventions: The new Medical Research Council guidance. *BMJ* **2008**, *337*, a1655. [[CrossRef](#)] [[PubMed](#)]
91. Freedson, P.; Bowles, H.R.; Troiano, R.; Haskell, W. Assessment of physical activity using wearable monitors: Recommendations for monitor calibration and use in the field. *Med. Sci. Sports Exerc.* **2012**, *44* (Suppl. 1), S1–S4. [[CrossRef](#)] [[PubMed](#)]
92. Peach, D.; Van Hoomissen, J.; Callender, H.L. Exploring the ActiLife((R)) filtration algorithm: Converting raw acceleration data to counts. *Physiol. Meas.* **2014**, *35*, 2359–2367. [[CrossRef](#)] [[PubMed](#)]

